Water Resource Report 41
1975

GROUND-WATER RESOURCES OF LACKAWANNA COUNTY, PENNSYLVANIA

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DEPARTMENT OF ENVIRONMENTAL RESOURCES
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GROUND-WATER RESOURCES OF LACKAWANNA COUNTY, PENNSYLVANIA

by Jerrald R. Hollowell
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U. S. Geological Survey

Prepared by the United States Geological Survey, Water Resources Division, in cooperation with the Pennsylvania Geological Survey

PENNSYLVANIA GEOLOGICAL SURVEY

FOURTH SERIES

HARRISBURG

1975

ADDITIONAL COPIES
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STATE BOOK STORE, P. O. BOX 1365
HARRISBURG, PENNSYLVANIA 17125

PREFACE

This report deals with the subsurface resources of an extremely complex geological area, further complicated by deep, abandoned anthracite mines and large-scale strip mines. The water demands of the large population centers in the area, as well as the need for controlling the quality of ground water issuing from the mines, give added importance to the results of the ground-water investigation which are presented in this report. These results should be of assistance to planners, construction people, industry, and home-owners, all of whom at various times deal with or are affected by the occurrence and quality of the subsurface water in the area.

Arthur A. Socolow

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GROUND-WATER RESOURCES OF LACKAWANNA COUNTY, PENNSYLVANIA

by

Jerrald R. Hollowell and Harry E. Koester

ABSTRACT

Lackawanna County comprises an area of about 450 square miles in northeastern Pennsylvania. The county is bisected by the Lackawanna Valley, part of a structural basin containing the Northern Anthracite field. Most of the population is concentrated in the valley, and many reservoirs were constructed in the mountains surrounding the valley to provide water to the communities below.

Since 1960, suburban development, spurred by the construction of superhighways, has been away from the valley onto the adjacent plateaus. This suburban development has created a demand for ground-water supplies.

The principal aquifer in Lackawanna County is the Catskill Formation. Other aquifers are utilized, but, because of their small areal extent, they are relatively unimportant. Ground water occurs mainly in bedding planes, joints, faults, and other fractures in the rocks. The density, size, and extent of interconnection of the openings determine the ability of the rocks to transmit and store water. Wells drilled into the fractured rock aquifer have yields that range from a half gallon to 300 gpm (gallons per minute). Wells drilled in valleys have a median yield of 50 gpm, which is about 40 times that of hilltop and hillside wells. High-yielding wells may be obtained throughout Lackawanna County along discrete zones of highly fractured rock. Wells in these zones have a median yield of 90 gpm. The Catskill Formation has a low storage capacity, and two or more high-producing wells along a highly fractured zone will have mutual interference. An observation well on the same fracture trace as a pumped well, which was more than 300 feet away, showed a drawdown of 1 inch after 8 hours of pumping at the rate of 100 gpm.

Some ground-water supplies may be obtained from isolated beds of sand and gravel deposited by outwash water from Pleistocene glaciers. Few wells are drilled into the unconsolidated aquifer. Two wells that tapped about 40 feet of sand and gravel yielded 48 and 163 gpm. Another well tapping 125 feet of sand and gravel yielded 300 gpm.

Water from most wells tapping the Catskill Formation is of good quality. It is low in dissolved solids and is primarily a bicarbonate type water. A few wells yield poor-quality water that is high in dissolved solids and is of the sodium bicarbonate and chloride types. Very few wells tested are known to be polluted, and in most of these the source of pollution is probably local. On-lot sewage-disposal systems are the main sources of pollution to ground water outside the Lackawanna Valley. In the valley, ground water occurs mostly as mine water and is high in dissolved solids.

Mine drainage enters the Lackawanna River at numerous points along its course in Lackawanna County. Those mine overflows at the upper end of the valley contribute the least amount of pollution to the river. Those overflows near Duryea and Old Forge drain the largest mined-out area and are the greatest polluters of the Lackawanna and Susquehanna Rivers. Dissolved-solids content of the Lackawanna River ranges from less than 30 mg/l (milligrams per liter) above Simpson to more than 1600 mg/l at the mouth.

INTRODUCTION

PURPOSE AND SCOPE

The development of water resources to meet increasing demands requires knowledge of the availability, distribution, quality, and use of water. Such information is essential to the orderly and economical planning, construction, and operation of facilities that will provide water to satisfy increasing needs. This study was made to provide such information on the available ground water in the county. The report also describes the distribution and movement of water in the underground mines and also the effect mine-water discharge has upon the Lackawanna River.

Many water-related problems exist in the county that inhibit, and in some places prevent, optimum ground-water development. The four major problems of low-yielding wells, inadequate supplies for public water companies, poor-quality water, and pollution are discussed.

This investigation was begun in 1967 as part of a continuing study of ground-water resources of Pennsylvania by the U.S. Geological Survey in cooperation with the Pennsylvania Geological Survey.

LOCATION OF THE AREA

Lackawanna County is in northeastern Pennsylvania (Figure 1). It is about 450 square miles in area, being about 20 miles wide (from east to west) and 33 miles long (from north to south). The county is bisected northeast to

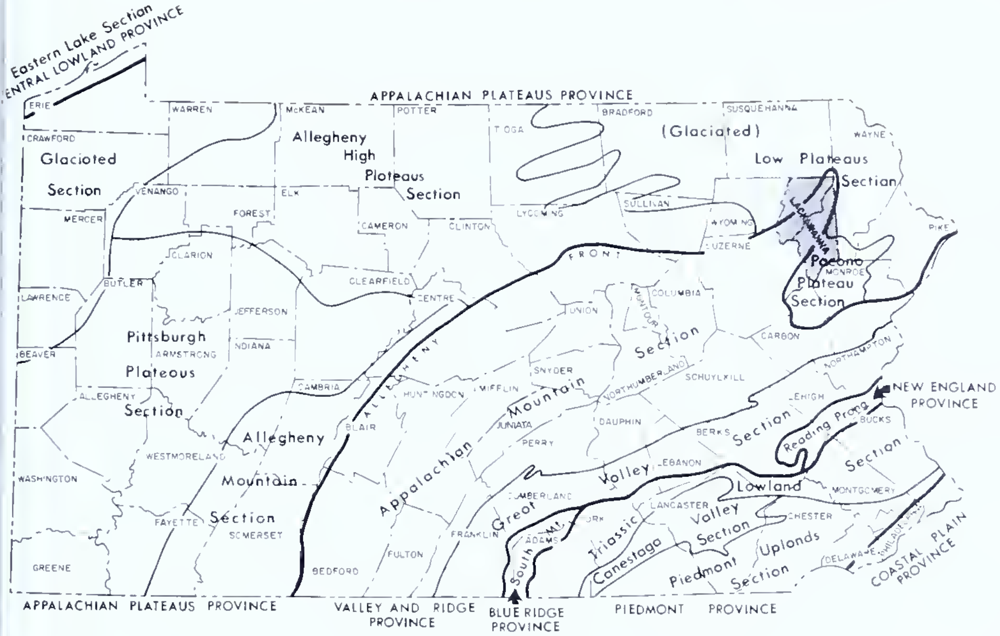


Figure 1. Physiographic provinces of Pennsylvania and location of Lackawanna County.

southwest by the Lackawanna Valley, a deep, elongate syncline that contains the Northern Anthracite field.

PREVIOUS INVESTIGATIONS

Several earlier investigations of the geology and water resources of the area have proven helpful in the preparation of this report. The ground-water resources of Lackawanna County are described by Lohman (1937), who made a reconnaissance of the ground-water resources of northeastern Pennsylvania. I. C. White (1883) first discussed the geology of Lackawanna County. The geology of the anthracite basin is also described in numerous annual reports by the Second Geological Survey of Pennsylvania. The structure of the Northern Anthracite field was described and illustrated by Darton (1940). The barrier pillars between underground mines in the anthracite basin are described by Ash and others (1952). Much of the Pocono Formation in Lackawanna County was mapped and described by Sevon (1969).

METHODS OF THIS INVESTIGATION

Information on well depth, depth to water, and yield was obtained from well owners, well drillers, and field measurements. Data from 400 wells are shown in Table 17 (p. 76). Long-term aquifer tests were made at six loca-

tions to determine transmissivities and storage coefficients for the Catskill Formation. One-hour tests were made at 48 locations to determine specific capacity of wells. Continuous water-level records were obtained from four wells. Water samples for chemical analyses were collected from 61 wells and 6 mine overflows. The analyses were made in the U.S. Geological Survey laboratory in Harrisburg, Pennsylvania. Aerial photographs of the county were used to map surface linear features—probably fracture traces. Geophysical logging was used to obtain subsurface data on wells.

WELL-NUMBERING SYSTEM

All wells inventoried have an identification number and a location number. The identification number is used for easy reference to a well during discussion, and consists of two parts. The first part is a two-letter symbol that identifies the county in which the well is located, for example, Lk for Lackawanna County. The second part of the identification number is a serial number assigned at the time the well is inventoried.

The location number identifies the geographic (or map) location of a well. The location number consists of two four-digit segments separated by a hyphen: the first segment is composed of the degrees and minutes that define the latitude on the south side of the 1-minute quadrangle in which the well is located; the second segment is composed of the degrees and minutes that define the longitude on the east side of the same 1-minute quadrangle (see Figure 2).

ACKNOWLEDGMENTS

The authors express their thanks to the many people who provided the data and technical assistance that made this report possible.

Many well drillers provided well data. Cresswell Drilling Company, Fritz Brothers, Robert Knight, Layne-New York Company, Inc., Stanley Thomas, Tully Drilling Company, Inc., and William H. Wolfe were extremely helpful and spent valuable time assisting the authors.

We also acknowledge the assistance of the managers and owners of the following companies: Clarks Summit Water Company, Waverly Water Company, Lomma Enterprises, Glenburn Water Company, and Pennsylvania Gas and Water.

Moody and Associates provided us with a report on the Clarks Summit Water Company that contained much useful material.

We also thank the many individual well owners who permitted us to test their wells, especially Mr. Fred Hilwig, who permitted us to drill an observation well on his property.

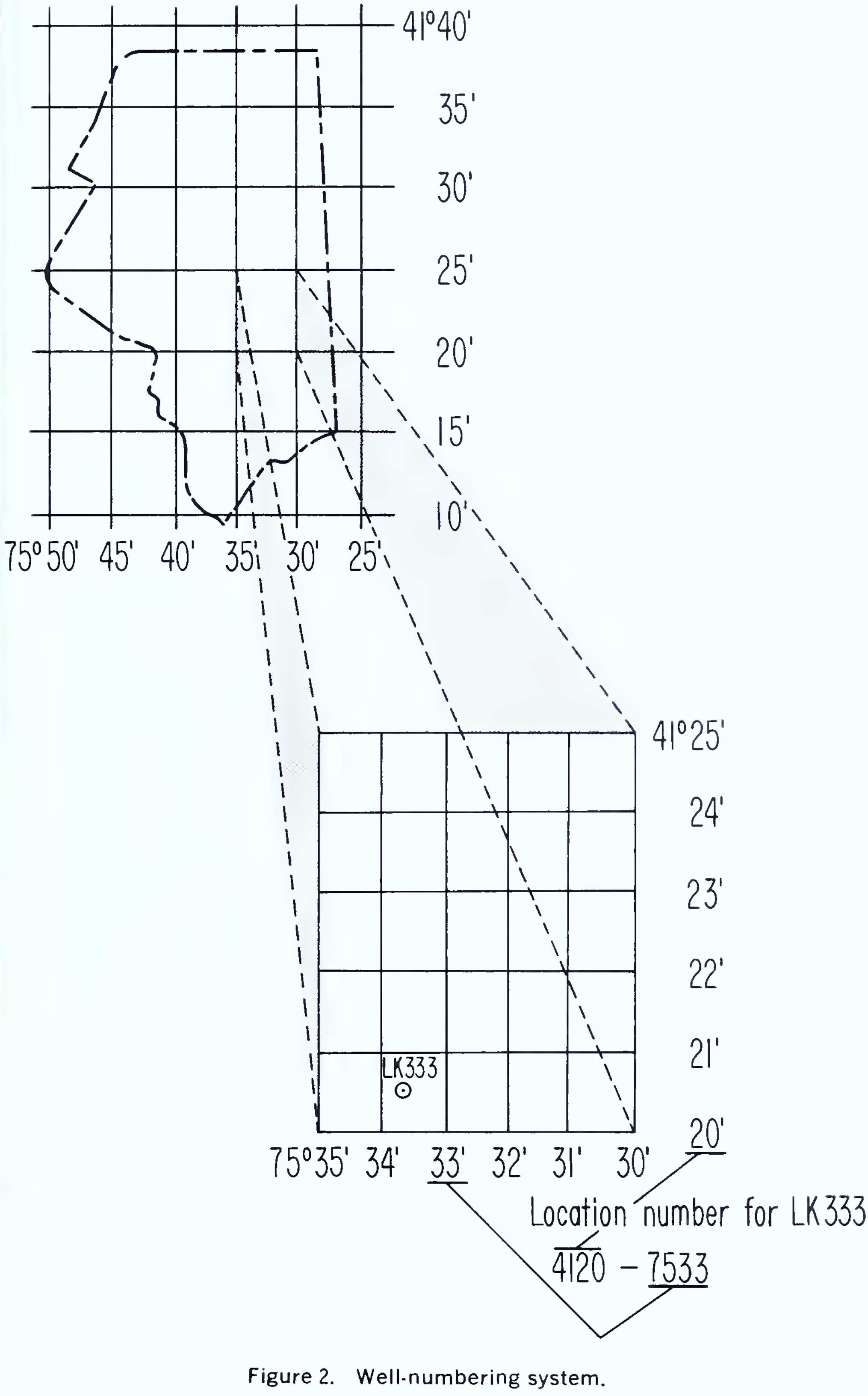


Figure 2. Well-numbering system.

GEOGRAPHY

PHYSICAL SETTING

Lackawanna County is bisected by the Lackawanna Valley, which is continuous from southeastern Susquehanna and western Wayne Counties to northeastern Luzerne County.

The county is drained by rapidly flowing streams. The Lackawanna River basin drains 348 square miles, mostly from the southern half of the county along the east slope of the Moosic Mountains. The Lehigh River drains the extreme southern part of Lackawanna County that borders Wayne and Monroe Counties, and Tunkhannock Creek drains the northwest part of Lackawanna County and flows into Wyoming County.

The main stem of the Lackawanna River is 40 miles long from its source in Susquehanna County to its mouth near Pittston. The gradient is steep in the headwaters, falling an average of 45 feet per mile in its descent to Carbondale. From Carbondale to Scranton, a distance of 15 miles, the gradient is 20 feet per mile, and from Scranton to the mouth of the river, the gradient is only 13 feet per mile.

The highest elevation in the county is 2,324 feet in the Moosic Mountains, and the lowest elevation is 540 feet at base level of the Susquehanna River near Ransom. Thus, the maximum relief is approximately 1,780 feet. The Lackawanna Valley is a large structural valley bounded by mountains, and the surrounding terrain is a gently rolling plateau with deeply incised canyons.

The area was completely glaciated and is now partly covered by a moderately fine textured soil derived from till. Many of the larger valleys have flat, floodplain-type bottoms. The smaller valleys contain many swamps, small lakes, and ponds. These features are the result of filling and constriction from glacial outwash. Moderately permeable sand and silt deposits are present in most of the valleys. Many of the swamps have abundant peat deposits in various stages of development.

PHYSIOGRAPHY

Lackawanna County lies in the Appalachian Plateaus province and the Valley and Ridge province (Fenneman and Johnson, 1946). The Plateaus province has been subdivided into the northern Allegheny Plateau section and the southern Pocono Plateau section (Pennsylvania Geological Survey, 1965). The geographic-physiographic relationships are shown on Figure 1.

That area included in the Valley and Ridge province is underlain by folded rocks in and adjacent to the Lackawanna Valley. The flat-lying rocks of the plateaus adjacent to the Lackawanna Valley are downfolded under the Lackawanna Valley and underlie the younger, more resistant units that form the mountains flanking the valley.

The rocks that underlie the Lackawanna Valley are downfolded into a canoe-shaped trough that contains the eastern half of the Northern Anthracite field. Mining of coal from this trough has created a vast underground network of interconnected voids that filled with water after cessation of mining.

CLIMATE

Topographic and structural features divide the county into temperature and precipitation zones. The average annual temperature is about 50°F for most of the county and ranges from 2 to 3 degrees lower for the mountainous areas in the southern part (U.S. Department of Commerce, 1964). Daily temperature ranges are wide, averaging about 20°F in midwinter and 26°F in midsummer. The average midsummer temperature ranges from 67°F in the east to 71°F in the west. The average annual midwinter temperature is about 24°F and ranges from 2 to 4 degrees lower on the extreme south and extreme northeast parts.

The average annual precipitation for 40 years of record ranges from 41 inches in the northwestern three-quarters to 48 inches in the extreme south and northeast parts. The average annual rainfall ranges from 34 inches in the north to 37 inches in the far south, and the average annual snowfall ranges from 43 to 54 inches, respectively. The annual precipitation on the Pocono Plateau varies considerably from year to year, but it averages 5 inches more per year than it does north of the valley.

INDUSTRY AND MINERAL RESOURCES

Scranton is the largest city in Lackawanna County, and its history dates back to 1786, when the Abbott brothers erected a sawmill on Roaring Brook near Nay Aug Park. In 1840, five anthracite blast furnaces were built by George W. Scranton, after whom the city was named (Craft, 1891). The city grew rapidly and established itself as the world's leading anthracite-producing locality. Since 1960, however, Scranton is principally a manufacturing city, and its wealth of coal has left it a legacy of mine subsidence, acid-mine drainage, underground mine fires, and burning refuse (culm) piles. Projects are in progress for restoration of the land and protection against mine subsidence. Underground and culm fires are being extinguished, and research is underway seeking solutions to the acid-mine drainage.

The employment picture for all of Lackawanna County shows a definite trend away from an economy based primarily on coal production. In 1971, textile mills and apparel producers employed over 40 percent of the labor force, electronics and electrical machinery accounted for approximately 10 percent, and food and tobacco manufacturers about 10 percent. Fabricators of metals, leather, and rubber products employed almost 20 percent; print-

ing and publishing about 7 percent; paper, chemicals, stone and glass, and furniture and transportation equipment manufacturers employed about 5 percent; and mineral production employed the balance, about 8 percent.

Industrial growth has occurred along sections that have immediate access to Interstate Route 81 and the Northeast Extension of the Pennsylvania Turnpike. Rapid industrial growth is envisioned for the Moscow area, off Interstate Route 81-E and 84 (not completed). These highways will provide easy access from points east and west to the North Pocono Mountain recreation area.

Mineral production includes minor amounts of coal, flagstone, sand, gravel, and peat moss. The latter is an increasingly important commodity, which is found on the plateau. Coal production reached its peak in 1917 and declined from over 20 million tons to approximately 400,000 tons per year in 1970.

The suburban and rural population shift has initiated a building boom away from the valley and onto the adjacent plateaus, both north and south, resulting in a substantial population increase in and around the lake areas. Much of this rapid development was unplanned and made the growth away from the larger cities a network of small towns and commercial centers.

Further population increases in Lackawanna County are anticipated in most suburban areas, especially in the rural sections along the Pocono Mountain area and south to Thornhurst and Gouldsboro.

POPULATION SHIFT

The urban populations in Lackawanna Valley have shown a decrease, corresponding with the rapid decline in anthracite production. The U.S. Census shows that the population decreased from 234,500 in 1960 to 234,100 in 1970 (U.S. Department of Commerce, 1971). This difference is a relatively small amount; however, the decline has been accompanied by a shift in population from urban to suburban and rural areas. The following table shows the population decline for the three major cities, which are located along the valley.

Population center	1930	1960	1970
Carbondale	20,061	13,595	12,808
Dunmore	22,627	18,917	17,300
Scranton	143,433	111,443	103,564

PUBLIC WATER SUPPLIES

Data on public water supplies and the areas served by them are presented in Table 19 (p. 100). The majority of households in the valley are favored

by an excellent supply of good water from numerous spring-fed streams that are artificially impounded along the perimeter of the valley.

Pennsylvania Gas and Water Company has many reservoirs as a source of water supply providing services in Susquehanna, Wayne, Lackawanna, and Luzerne Counties. The impounded waters are located in the Lackawanna and Susquehanna River watersheds and have a total capacity of approximately 19.6 billion gallons. The company has 76 reservoirs and 35 distribution points, which serve the area from Forest City to Wilkes-Barre, Pennsylvania, a distance of over 70 miles. It serves 130,000 customers, representing a total population of over 475,000. Growth in the number of services has been meager in recent years.

The Pennsylvania Gas and Water Company in Lackawanna County serves a population of approximately 140,000. Analyses of water from reservoirs supplying the Carbondale, Dunmore, and Scranton and Wilkes-Barre areas are listed, with their source and storage capacities, in Table 1.

Among the major users of the surface- and ground-water supplies along the Lackawanna and Wyoming Valleys are industries drawn to the area by its natural resources, including its excellent water supplies. About 90 percent of the manufacturing plants in the valley are small and require small supplies of water. Plants using the largest amount of water include the following, in order of amount used: food and tobacco producers; apparel manufacturers; lumber and wood producers; printing and publishing; machinery manufacturers; and stone, brick, glass, and concrete manufacturers. The largest amount of water used by industry is for cooling, a use not particularly sensitive to poor water quality. Much of the river water polluted with mine drainage may be adapted to possible future requirements with modest treatment. Recirculation of water has not been the practice except in cooling and steam generating.

Most of the water supplies for small factories, commercial establishments, institutions, communities, boroughs, and municipalities located outside of the valley are obtained from wells or are supplemented by wells.

WASTE-WATER DISPOSAL

About 90 percent of the municipalities in the county provide only primary treatment, or less, of their sewage discharges. Primary treatment of sewage involves the use of screens, removal of grit and suspended solids (sludge), and finally the chlorination of effluent. Secondary treatment removes up to 90 percent of the organic matter in sewage by bacterial decomposition. The effluent is aerated, and chlorination completes the treatment. Efforts are currently (1971) underway to provide advanced sewage-treatment plants for the Lackawanna Valley. Most of the newer utilities include secondary processes.

Table 1. *Public Water Supplies Owned by Pennsylvania Gas and Water Company*

Data from Lohr and Love (1954)

(values in milligrams per liter, unless otherwise indicated)

	Carbondale		Dunmore	Scranton	Scranton Wilkes-Barre
Source (reservoirs and wells)	Fall Brook and Brownell Reservoir	Reynshan-hurst Well and Reservoir	Dunmore # 1 and Williams Bridge Reservoirs	Lake Scranton, Elmhurst, and Chinchilla Reservoirs	Spring Brook, Gardner's Creek, and Nesbitt Reservoir
Storage capacity (gallons)	1 billion	0.5 billion	0.5 billion	3 billion	2.7 billion
Silica (SiO_2)	2.1	1.9	1.0	3.7	2.2
Iron (Fe), total	.24	.20	.03	.02	.00
Calcium (Ca)	7.6	2.3	1.0	7.8	4.0
Magnesium (Mg)	1.6	1.3	1.7	1.5	1.6
Sodium + potassium (Na + K)	1.7	1.5	7.8	1.3	2.3
Bicarbonate (HCO_3)	16	3	10	6	10
Sulfate (SO_4)	11	8.5	11	15	8.5
Chloride (Cl)	3.0	1.9	4.4	5.0	3.0
Fluoride (F)	.0	.0	.0	.0	.0
Nitrate (NO_3)	.5	.5	.6	1.0	.5
Residue on evaporation (ROE)	38	24	40	55	38
Total hardness	26	11	10	26	17
Noncarbonate hardness	12	9	1	21	8
pH	7.4	6.6	7.0	6.3	7.1
Specific conductance (micromhos)	66	31	57	70	53

Sewage from individual households is commonly treated by on-lot septic tanks. The septic tank is safe in most rural areas, providing the tank and drainfield are located so that the effluent drains away from the water-supply well. As population and urbanization increase throughout the plateau areas, septic tanks may cause ground-water pollution.

GEOLOGY[1]

The bedrock of Lackawanna County has been classified on the geologic map (Plate 1), from oldest to youngest units, as follows: the Catskill Forma-

[1] The geologic nomenclature in this report is that of the Pennsylvania Geological Survey and does not necessarily coincide with that of the U.S. Geological Survey.

tion, of Devonian age; the Pocono Formation, of Mississippian and Devonian age and the Mauch Chunk Formation, of Mississippian age, which are undifferentiated on the map; and the Pottsville and Llewellyn Formations, of Pennsylvanian age, which are also undifferentiated on the map. The Llewellyn Formation contains the coal beds mined in the Northern Anthracite field.

The bedrock is well exposed on the resistant ridges and in deep cuts where the overlying glacial deposits have been largely removed by erosion. Very few natural exposures of bedrock occur in the Lackawanna Valley and in the rolling uplands of the plateau. The rock formations are described from oldest to youngest in the following sections.

BEDROCK STRATIGRAPHY

Catskill Formation

The Catskill Formation is exposed in the northern and southern parts of Lackawanna County and makes up much of the mountains flanking the Lackawanna Valley (Plate 1). The formation is about 6,000 feet thick in the northeastern part of Pennsylvania; however, only about half of it is exposed in the county. The base of the formation was reached by test wells drilled on the White Deer anticline (Kehn and others, 1966, p. 20).

The Catskill Formation is composed of dark-grayish-red to reddish-brown shale, claystone, and siltstone; greenish-gray and dark-grayish-red, fine- to medium-grained sandstone; and yellowish- to greenish-gray, medium- to coarse-grained sandstone and conglomerate. Small amounts of grayish-brown calcareous conglomerate and greenish-gray conglomerate mudstone are present locally. Crossbedding, channeling, and cut-and-fill features are typical of the sandstone and conglomerate units. Bedding is not distinct in the shale, claystone, and siltstone units. About half of the formation exposed in this area is composed of sandstone and coarser grained rocks, and the other half is composed of finer grained rocks. Siltstone predominates in the lower part of the formation.

The sample log for well Lk-318 (Table 18, p. 92) is typical of the lithology penetrated by most of the water wells drilled in the Catskill Formation. It shows the alternating colors and grain sizes of an almost completely clastic suite of residual minerals in which quartz predominates.

Wells Lk-89, 99, and 388 were drilled on fractures. Logs for these wells show a much larger mineral suite, consisting of chemical precipitates as well as the common clastic residuals. The upper fracture zones are frequently free of chemical precipitates and are either filled by fine clastics or not filled at all. Samples from well Lk-388 contained a light-brown porous calcareous bog ore that filled voids in the fracture crevices. The bog ore contains 7.6 percent iron, 0.7 percent manganese, and trace amounts of zinc, copper, and lead.

Ore found in the gulches along the south side of Lackawanna Valley (Craft, 1891) was used in the manufacture of iron. The ore was located near Moosic Mountain, halfway between Nay Aug furnace and Stafford Meadow Brook. The ore contained 25 percent iron and 50 percent carbonate (Platt, 1887).

Samples from well Lk-99 contained rock fragments coated with a black chemical precipitate. This material was analyzed and found to be calcareous. It contained 59 percent iron, 0.4 percent manganese, and traces of zinc, copper, and nickel.

Chemical precipitates generally increase as depth increases within a fracture. Carbonates, especially vein calcite, are most common and were found in all wells sampled. Selenite crystals were found in samples from well Lk-99.

Many of the wells sampled penetrated some beds containing disseminated pyrite, mica, and carbonaceous shale; most of these wells encountered some fragments of fossil plants and coal. All wells sampled contained some rock fragments that were stained by iron and manganese. The color of the staining depends on the local redox potential of both the sediments and the recharge water in the environment.

Pocono and Mauch Chunk Formations

The Pocono Formation crops out in two belts along the margin of the Lackawanna syncline. It is about 600 feet thick at the west boundary of the county, more than 750 feet thick at Nay Aug, and thins eastward until it disappears east of Pa. Route 611 and Interstate Route 81 (Plate 1). The Mauch Chunk Formation overlies the Pocono and is primarily a red calcareous shale. It is only a few feet thick at the west boundary of the county (Kehn and others, 1966, p. 29) and disappears within a mile to the northeast. The Mauch Chunk and Pocono Formations are undifferentiated on the geologic map (Plate 1).

The Pocono Formation is composed mainly of yellowish-gray, light-olive-gray, and light-grayish-green sandstone, conglomerate, and conglomeratic sandstone. Some yellowish-gray and light-greenish-gray siltstone and shale are interbedded with the coarser grained rocks. A conglomeratic unit present northeast of Scranton weathers to a light-gray color.

The basal unit of the Pocono is exposed along the southern flank of the Lackawanna Valley west of Pa. Route 611 and on the north side of the valley west of Scranton. It attains a thickness of as much as 300 feet near Nay Aug. This unit, described in detail by Sevon (1969, p. 5-15), is a massive conglomeratic claystone made up of clay- to boulder-sized particles. Characteristically, it resembles a tillite and is referred to as a tilloid. Well-rounded pebbles and cobbles (as much as 4 inches in diameter) and silt and sand

grains are scattered throughout the matrix. The fresh rock ranges from dark gray to light olive gray and weathers to dark yellowish brown and brownish gray. The tilloid grades upward into a pebbly mudstone, having a dominant grain size ranging from clay to coarse-grained silt. Some laminae are present. Sand grains, pebbles, and cobbles (as much as 3 inches in diameter) are scattered throughout the unit, but are less abundant than in the tilloid. The mudstone grades upward into a light-olive-gray laminite composed of coarse-grained silt or very fine grained sand alternating with clay laminae.

The overlying unit (Sevon, 1969, p. 15–18) is a thick series of well-sorted rippled and planar-bedded sandstones. The sandstone unit is more than 150 feet thick near Scranton and is composed of well-sorted fine- to medium-grained quartz. On the north side of the Lackawanna Valley this unit contains beds of conglomerate.

The topmost unit in Lackawanna County (Sevon, 1969, p. 18-20) is composed of massive sandstone grading upward into thin-bedded siltstone and shale, massive siltstone, limestone, calcareous sandstone, and some conglomeratic sandstone.

Pottsville Formation

The Pottsville Formation crops out on the flanks of the Lackawanna syncline (Plate 1). It is about 250 feet thick at the west boundary of the county and thins northeastward to about 35 feet at the apex of the syncline near Forest City, Wayne County. The lowest 20 to 50 feet of this formation crops out as an almost continuous ledge of white conglomerate. The conglomerate consists of silica-cemented quartz pebbles that range from one-fourth to 3 inches in diameter. The upper beds are composed of finer grained and softer rocks, such as small-pebble conglomerate, fine- to coarse-grained sandstone, siltstone, and, locally, thick beds of carbonaceous shale and coal. The top of the Pottsville Formation is marked by the base of the shale that underlies the lowest persistent economically important anthracite bed.

Llewellyn Formation

The Llewellyn Formation overlies the Pottsville Formation, and a maximum of 830 feet of this formation remains in the Lackawanna Valley. The Llewellyn underlies the Lackawanna Valley and the lower slopes along the north side of the valley. The strata are poorly exposed, because they are mostly covered by soil mantle, glacial debris, mine waste, and urbanization. The Llewellyn is composed of interbedded strata of light-gray, yellowish-gray, and greenish-gray quartz granules and pebble conglomerate; light- to medium-gray and yellowish-gray fine- to coarse-grained and finely conglomeratic sandstone; light-gray to dark-gray siltstone; medium-gray claystone; light-greenish-gray to dark-gray shale; dark-gray to black car-

bonaceous shale; and coal beds. Crossbedding, truncated bedding, cut-and-fill structures, and channel outlines are common in most of the strata. The coal beds are the most persistent units; strata between coal beds are typified by extreme lateral changes in thickness and lithology. At least 17 coal beds are present in the Lackawanna coal basin. They range in thickness from a few inches to about 14 feet.

BEDROCK STRUCTURE

Folds

The principal structural feature in the county is the Wyoming-Lackawanna syncline. It enters the northeast corner of the county as a shallow trough and gradually deepens and broadens southwestward, toward the Wyoming Valley, Luzerne County.

The dips of the rocks flanking the syncline are less than 10 degrees at the northeast end and become greater to the southwest, where they reach 22 degrees near the Luzerne County line (Kehn and others, 1966, p. 36).

The rim rocks bordering the Lackawanna Valley (Pottsville and older) suggest a simple synclinal structure. However, the Llewellyn Formation is folded into a series of small anticlines and synclines. A large syncline trends about N70E between Scranton and Archbald (Darton, 1940, pl. 10). The smaller synclines trend oblique to the general orientation of the basin, and strike about N45E. These structures are discontinuous and are seldom more than a few miles in length. Near the Lackawanna-Luzerne County line, a structural high, the Moosic anticline, effectively delineates the Lackawanna basin from the Wyoming basin. The smaller structural basins have individual underground mine pools that overflow near the downstream terminus of each structure.

The White Deer anticline (Kehn and others, 1966, p. 36) is a gentle anticlinal fold that extends northeastward from Luzerne County through Tompkinsville and Waverly and gradually disappears northeastward. Its axis, in general, trends parallel to the Lackawanna Valley. The anticline is asymmetric and plunges about 1° NE. Its northwest flank dips locally about 3 degrees near the crest (Kehn and others, 1966, p. 36), and the dip gradually diminishes away from the crest until it is about 1° NW. Dips in the northwestern and southeastern parts of the county are generally horizontal.

Fractures

Rupture deformation produces joints, faults, and certain types of cleavage in all rocks. Joints (breakage planes along which no visible movement has occurred) are the commonest type of fracture. The data for 214 vertical-joint measurements indicate that the rocks are systematically jointed and that the

joints have two markedly preferred orientations. One prominent joint set trends north to N10E on the north side of the Lackawanna Valley and north to N20E on the south side of the valley (Figure 3). The other prominent set trends nearly east-west on both sides of the valley. Joints commonly are well developed in competent sandstone and siltstone beds that are interbedded with less competent beds of shale. Generally, only one or two joint sets are well developed, but three well-developed sets occur in some outcrops and four sets are present in a few outcrops. Most of the joint sets are vertical or nearly vertical.

The orientation and magnitude of earth stresses largely control the size, density, and orientation of fractures produced in a single rock type. The most common fracturing in Lackawanna County is that associated with folding and faulting. Loading of sediments can produce faulting and fracturing in brittle units sandwiched between more ductile units.

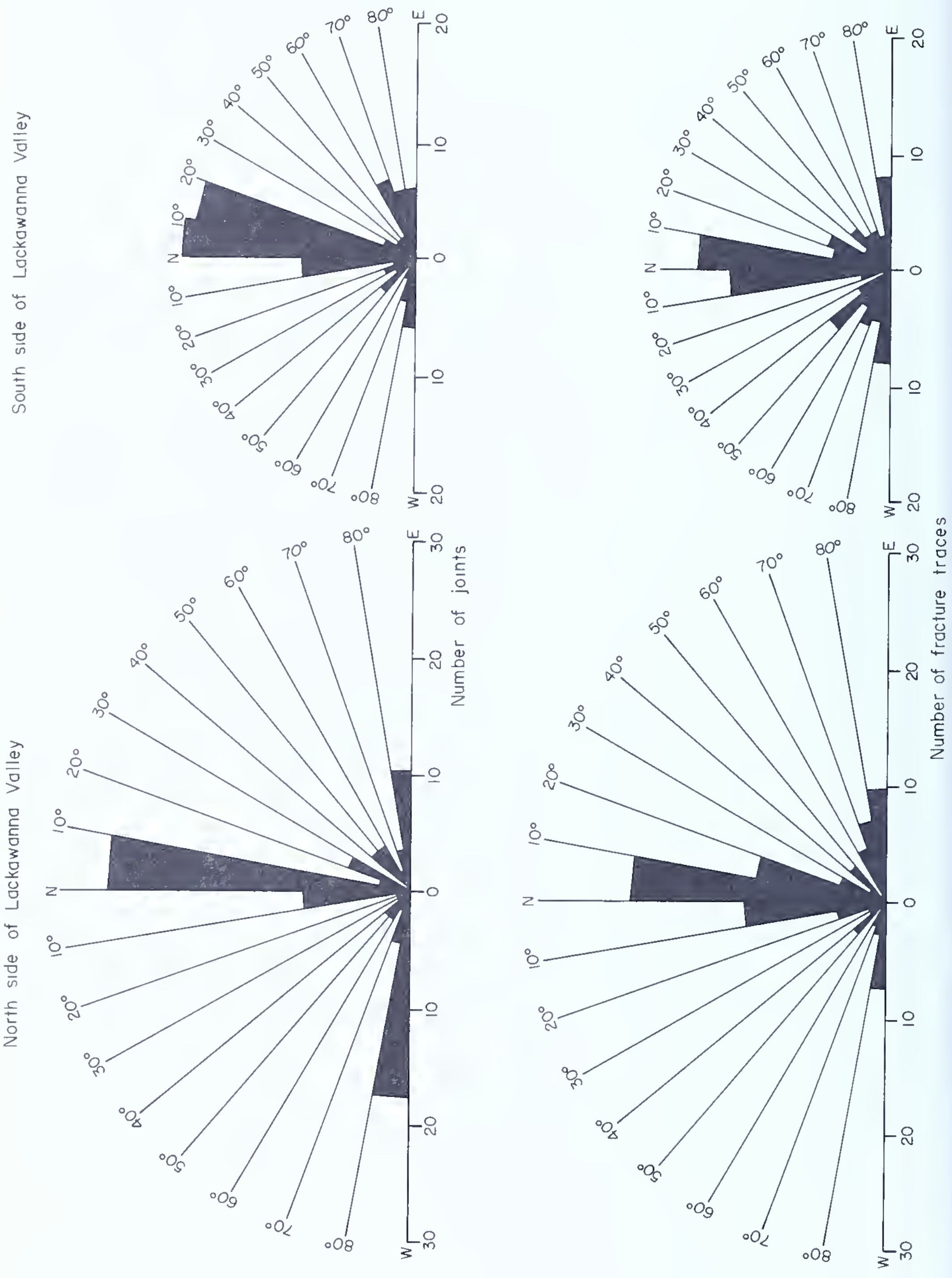
In the Catskill Formation, brittle sandstone beds, with interbedded shale and siltstone, were subjected to differential stress during loading and unloading. Unloading by erosion caused joints to form, owing to unequal distribution of stresses, which, in turn, accelerated erosion. Additional stresses resulted from the additional and the subsequent melting of hundreds of feet of ice and the rapid removal of glacial debris by Pleistocene floods (Peltier, 1949, p. 9).

Fracture traces and lineaments are natural linear features that are visible on aerial photographs and are probably surface expressions of fractures in the underlying rock. In areas underlain chiefly by fractured rock, such as the present study area, where most of the ground water occurs in fractures rather than in pore spaces, a knowledge of the location of the fractures is helpful in developing ground-water supplies.

According to Lattman (1958, p. 569), fracture traces consist of topographic (including straight stream segments), vegetational, or soil-tonal alignments that are visible primarily on aerial photographs and are expressed continuously for less than 1 mile. Similar features that are expressed continuously for at least 1 mile and continuously or discontinuously for several miles are defined as lineaments and are considered to be the result of deep-seated movements.

Fracture traces do not include linear features that are obviously related to bedding, striation, foliation, and stratigraphic contacts. They are probably related to individual joints, zones of closely spaced joints, or small-scale faults. Inasmuch as these features remain straight over irregular topographic surfaces, they are probably steeply inclined. Traces of slightly to moderately inclined fractures would be sinuous in areas of substantial relief and would probably not be recognized as fracture traces on aerial photographs.

Fracture traces were identified and plotted on photographs at a scale of approximately 1:20,000 with the unaided eye and then with a pocket stereoscope. These fracture traces are shown on Plate 1.


South side of Lackawanna Valley
North side of Lackawanna Valley
Number of joints
Number of fracture traces

Azimuths of the 425 fracture traces plotted on Plate 1 were determined and grouped into 10-degree divisions. The distribution of these groupings is shown in the diagram on Figure 3. The fracture traces have a pronounced NO-10E trend and a less prominent east-west trend. Comparison of the rose diagrams for the orientation of joints and fracture traces shows a close agreement in trends. Because fracture traces and lineaments have, in part, different origins than joints, complete agreement is not to be expected.

SURFICIAL DEPOSITS

The unconsolidated deposits overlying the bedrock in Lackawanna County are mostly glacial debris in the form of till, moraine, outwash, and kame terraces; post-glacial alluvial deposits; and deep-mine and strip-mine wastes. Those deposits of glacial outwash thought by the authors to be of sufficient thickness to provide large supplies of water to wells are delineated on Plate 1.

Pleistocene Deposits

The deposits of clay, silt, sand, and gravel that cover most of the bedrock were deposited by glacial or glaciofluvial action during the Pleistocene Epoch and underlie the thinner Holocene deposits in stream valleys. Ice sheets covered the county during the Illinoian and the Wisconsinan glaciations. The ice advance during the Wisconsinan largely obliterated or modified effects of earlier advances. The line limiting the southern extent of the last ice advance is marked by hills of sand and gravel that accumulated at the terminus of the glacier in the southern part of the county. To the north the ground is mostly covered with a heterogeneous accumulation of debris, called till, left behind when the ice sheets receded. Much of this debris has been washed away on the steep hillsides, but extensive deposits are penetrated by wells along the lower mountain slopes and in the valley bottoms. Glacial drift deposited directly from the ice with little or no sorting is as thick as 265 feet in places.

Streams of meltwater from the receding ice reduced much of the debris to sand and rounded gravel that was deposited as kame terraces and outwash deposits. Kame terraces may be seen along the Lackawanna and Susquehanna River valleys. Outwash deposits are found in all large river and creek valleys in Lackawanna County and, locally, are suitable aquifers for large production wells. Kame terraces and outwash deposits are mined locally for sand and gravel. Because of the demand for sand and gravel, many kame deposits of small aerial extent have been completely removed. These deposits are described in more detail by Itter (1938) and Peltier (1949).

Holocene Deposits

The period since the ice of the glacial epoch withdrew from continental North America is known as the Holocene Epoch. In Lackawanna County, little deposition has taken place during this time. Locally, streams coming down the mountainsides have deepened their old valleys, and many, such as Roaring Brook (Itter, 1938, p. 30) have cut a new channel in hard rock. Material removed by these streams has been deposited along the Susquehanna River and, to a lesser degree, along the Lackawanna River.

The alluvial deposits occur in and along the large stream and river channels as channel fill and as a veneer of sediment left by floodwater in low-lying areas adjacent to streams. Overbank deposits are a few inches to a few feet in thickness and consist mostly of silt and very fine sand. The channel-fill deposits range from a few inches to 10 feet in thickness (Hollowell, 1971, p. 17) and consist of sand and gravel that are not readily discernible from the glacial-outwash deposits.

HYDROLOGIC CYCLE

The hydrologic cycle is the continuous movement of water on its journey from the atmosphere to the earth and back to the atmosphere. A diagrammatic annual hydrologic cycle for Lackawanna County is shown in Figure 4. Subsurface inflow and outflow is very small. Also, changes in ground-water storage over a period of years are negligible. Therefore, for an average year, the amount of precipitation equals the amount of runoff plus the amount of water lost by evapotranspiration. In northeastern Pennsylvania about 50 percent of the annual precipitation is returned to the atmosphere through evapotranspiration. The average annual runoff ranges from 21 inches on the northwestern part of the county to 27 inches on the southeastern part. Ground-water infiltration is estimated to range from 13 to 14 inches. In the Lackawanna Valley, where deep underground mining has altered the surface-water regime, evapotranspiration is probably reduced because of the destruction of vegetation and soil cover and the increased rate of seepage into the mines.

GROUND WATER

PRINCIPLES OF OCCURRENCE

Ground water is that subsurface water in the saturated zone—the zone in which all the spaces or interstices in the rocks, ideally, are filled with water under pressure equal to or greater than atmospheric pressure.

Rocks that are capable of yielding usable supplies of water to wells or springs are called aquifers. The openings that contain and transmit water

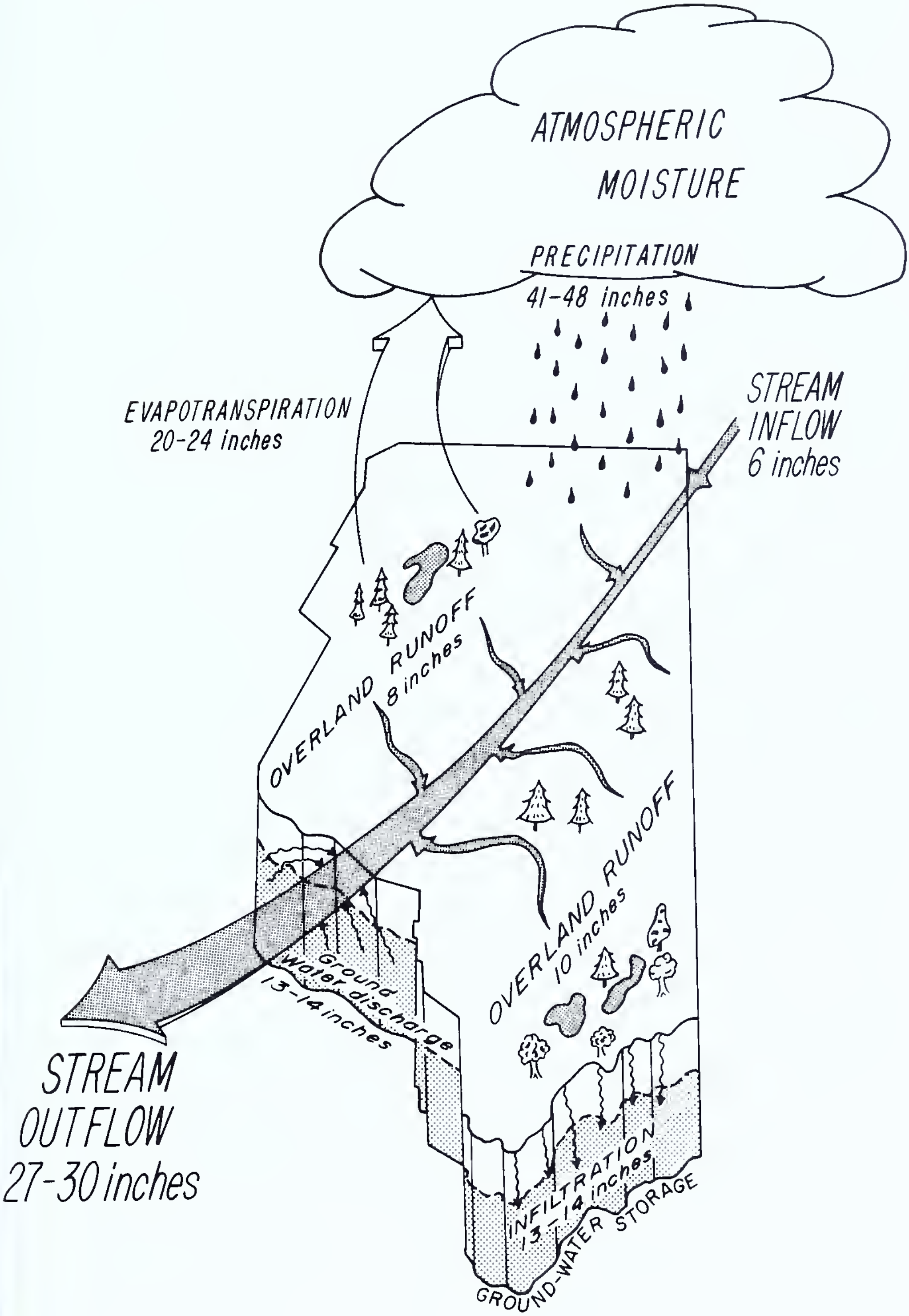


Figure 4. The annual hydrologic cycle and water budget for Lackawanna County.

in an aquifer are classified as primary and secondary. Primary openings are those formed during deposition of the sediments. The secondary openings are formed as a result of crustal movements, solution, or rock-weathering processes that take place after the rock is formed.

Water in the unconsolidated deposits fills the interstices between the individual grains of silt, sand, and gravel. In Lackawanna County, the unconsolidated deposits are only locally of significant thickness and permeable enough to be used as an aquifer. These areas are shown on the geologic map, Plate 1.

Water in the consolidated rocks of Lackawanna County occurs almost entirely in the secondary openings. Water-filled openings along bedding planes, joints, and faults can supply small to moderate amounts of water for domestic and farm use. Where these openings have been enlarged by solution, larger amounts of water are available for industrial and municipal use. The number and size of the openings and the degree of interconnection between them determine the ability of the consolidated rocks to store water and to transmit it to wells and springs.

Ground water is usually divided into two classes: (1) that which occurs under artesian conditions, and (2) that which occurs under water-table conditions. Under water-table conditions, ground water is not confined where the pressure is atmospheric, and the upper surface of the zone of saturation, called the water table, is free to fluctuate. Water in the unconsolidated deposits in Lackawanna County occurs under water-table conditions. Where water is confined under hydrostatic pressure in a permeable rock by relatively impermeable overlying rocks, the water is under artesian conditions. When an artesian aquifer is penetrated by a well, the water will rise in the well above the upper surface of the aquifer to a level called the potentiometric surface.

In the consolidated rocks of Lackawanna County, water is confined within crevice openings, the rock walls of the channels acting as the impermeable confining material. When a well penetrates such water-bearing openings, the water level rises in the well above the level of the opening. The well might be considered artesian; however, the rocks do not contain any impermeable beds, and the water occurs under water-table conditions.

RECHARGE, CIRCULATION, AND DISCHARGE

Recharge of ground water is the addition of water to ground-water reservoirs. It is accomplished mainly by infiltration of precipitation. Recharge is greatest where precipitation infiltrates the ground through thick unconsolidated rocks, which have superior infiltration characteristics. Water moves within the zone of saturation, under the influence of gravity, downward and laterally through rock openings from areas of recharge

(where hydraulic potentials are low). Ground water discharges into streams, either directly or through springs, and constitutes the base flow of perennial streams, such as Tunkhannock Creek and Spring and Roaring Brooks.

Under natural conditions and over long periods of time, the amount of water discharged from the zone of saturation is equal to the amount of water recharged to the zone of saturation. Ground-water levels fluctuate in response to recharge and discharge—rising when recharge exceeds discharge and declining when discharge exceeds recharge.

On the plateau, the water table is mostly near the surface, except under the hills where the topographic relief is great. Much of the precipitation on the ground remains near the surface, and approximately half is removed finally by evapotranspiration. Many of the numerous springs on the plateau mark places where the water table intersects the land surface at topographic lows. The springs are mostly the result of a wet-weather discharge (including snowmelt), and their flow is not sustained during dry periods.

Over most of the county, water enters the ground-water reservoir through unconsolidated deposits and then moves into the bedrock. Around low-lying areas in places of extreme vertical relief, water may move from the bedrock into overlying unconsolidated deposits and seep into streams, low floodplain deposits, or lakes, The slow but steady movement of ground water into streams maintains dry-weather flow. The maximum movement of ground water in the saturated zone occurs in the coarse outwash deposits, in the zone of weathered bedrock, and in the fractured-rock zones. The distance from point of infiltration of water to point of discharge is probably short, usually not more than 1 mile.

Available information on the vertical distribution of water-bearing zones in the Catskill Formation is presented in the following table. The 127 wells used in the compilation are fairly randomly distributed throughout the county.

Ratio of Number of Water-Bearing Zones of Specified Depth Range to Number of Wells Penetrating the Range

60–100 feet	101–200 feet	201–300 feet	301–400 feet	401–500 feet	501–600 feet
$\frac{32}{126}$	$\frac{97}{121}$	$\frac{65}{76}$	$\frac{20}{41}$	$\frac{9}{24}$	$\frac{4}{11}$

The depth-frequency distribution of water-bearing zones may be reasonably estimated from a graph based on a composite of the data in the above table. This curve, which is based on data for 20-foot intervals, is presented in Figure 5.

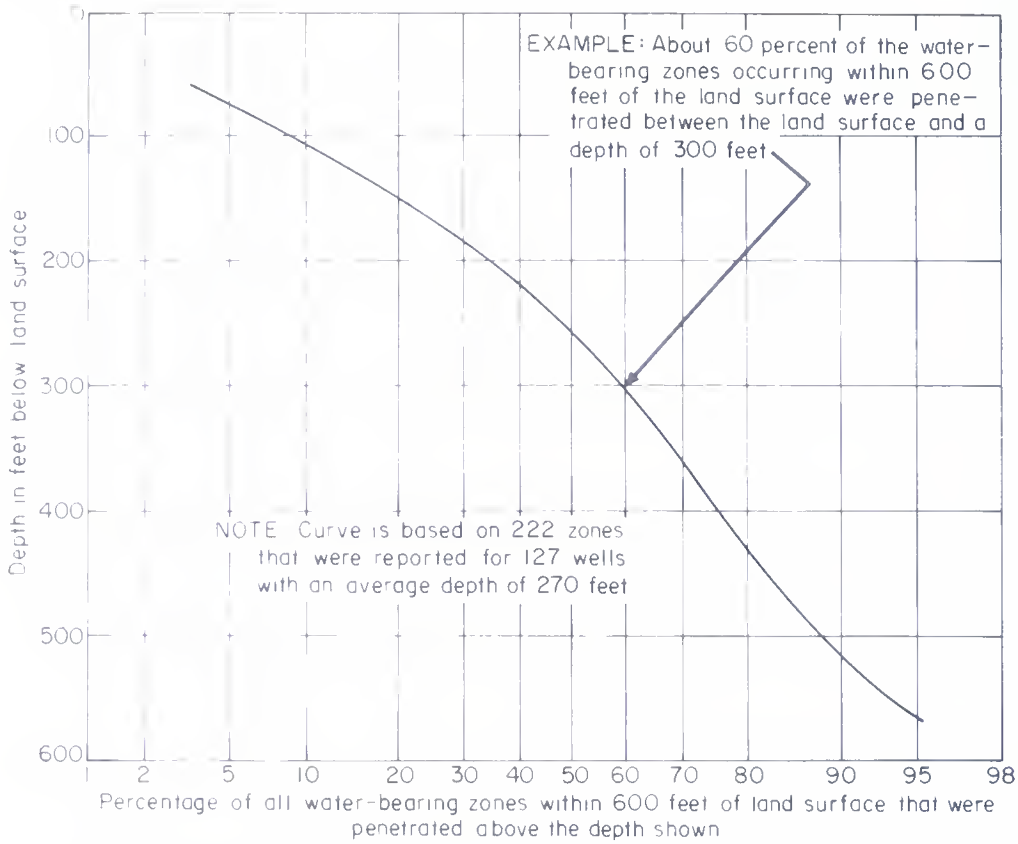


Figure 5. Distribution of water-bearing zones with depth in the Catskill Formation.

To a depth of 100 feet the shape of the curve has been influenced by the amount of the sample data included above the water table and the failure of drillers to report shallow water-bearing zones. Below a depth of 600 feet, too little borehole footage was inventoried to make a reliable estimate of the trend of the curve.

WATER TABLE

The water table in Lackawanna County, in general, conforms to the topography, as shown by the contour map (Plate 2). Depths to the water table range from 0 to 310 feet below land surface. In most valleys the wells flow or have shallow water levels. The depth to water in 50 hilltop wells ranged from 40 to 375 feet below land surface and averaged 160 feet. Those wells having water levels below 300 feet are in the highlands near the Susquehanna River.

At any one place the depth to the water table fluctuates throughout the year. Water-level fluctuations are caused by changes in the rate of recharge to the discharge from the aquifer. Generally, the water table is highest from March through June, when recharge is large, and it declines rapidly through

the late spring and summer because of evapotranspiration. Water levels begin to rise again in October, after the end of the growing season, and reach a peak in the early spring.

Hydrographs showing water levels observed in two wells are shown in Figure 6. Well Lk-240 is in the unconsolidated aquifer, and well Lk-187 is in the consolidated aquifer. The water-level fluctuation is less than 2 feet in the unconsolidated aquifer and greater than 8 feet in the consolidated aquifer.

The large water-level fluctuation in the consolidated aquifer is primarily due to the small storage capacity of the eonsolidated aquifer. The smaller water-level fluctuation in the unconsolidated aquifer is mainly a function of storage; however, well Lk-240 is located near a perennial stream that further dampens the fluctuation.

HYDROLOGIC PROPERTIES

Unconsolidated Deposits

The quantity of water that the unconsolidated glaeial outwash deposits will yield to wells depends primarily upon the thickness of the saturated material, the length of that part of the well open to the aquifer, and the transmissivity and storage coefficient of the aquifer.

Transmissivity (T) is a measure of the ability of the aquifer to transmit water. It is the rate at which water of the prevailing kinematic viseosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient.

The storage coefficient (S) is a measure of the ability of the aquifer to store water. It is the volume of water the aquifer releases from or takes into storage per unit surface area of the aquifer per unit ehange in the eomponent of head normal to that surface.

Transmissivity and storage coefficients are determined in the field by pumping a well at a given rate and measuring, at frequent intervals, the declining ground-water level in the pumped well and nearby observation wells. The rate at which the expanding cone of depression develops allows computation of transmissivity and storage by formulas devised by C. V. Theis and modified by C. E. Jacob (Ferris and others, 1962).

In unconsolidated deposits, transmissivity and storage vary with the size, shape, sorting, and packing of the aquifer material. Data are available from two aquifer tests in unconsolidated aquifers. One is in the East Benton Valley. The valley is composed of till and lake sediments, containing meandering narrow channels of sand, gravel, and cobbles. One well (Lk-240) was drilled into a channel deposit several feet thick. The well was tested by pumping at 300 gpm for 46 hours by Layne-New York Company, Inc. The caleulated

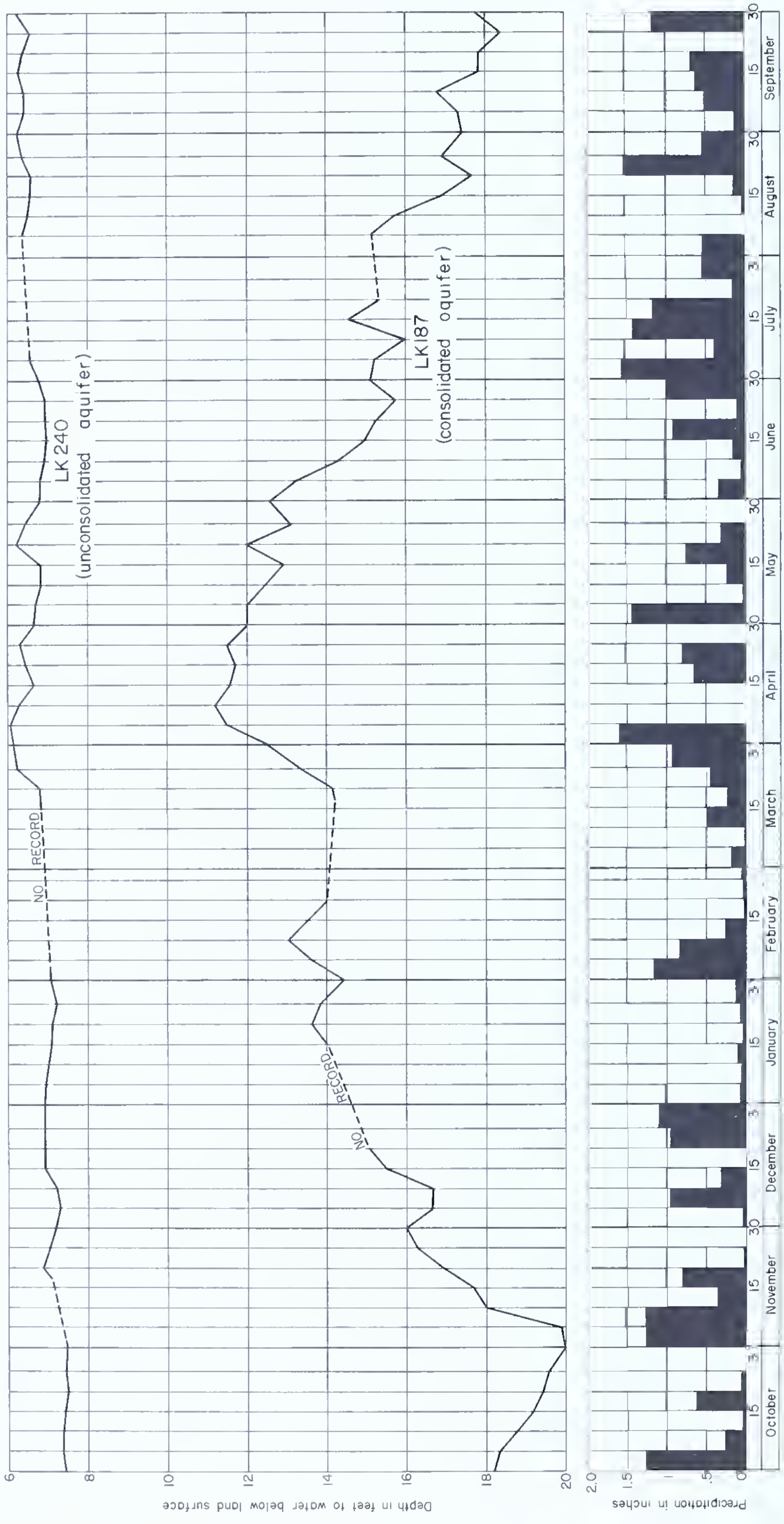


Figure 6. Hydrograph of wells in unconsolidated and consolidated aquifers and 5-day precipitation totals for Scranton.

transmissivity was 4,700 $ft^2\ day^{-1}$ (feet squared per day), and the coefficient of storage was 0.02. These results indicate that a properly constructed production well in this aquifer could produce 300 gpm (gallons per minute). Pumping this well would induce recharge from a nearby stream and swamp, and this would help to sustain the yield of the well. Numerous wells with similar yields could be developed in the valley, although test drilling would be required to locate the buried channels.

Wells Lk-390 and 391 were drilled in the Roaring Brook valley, east of Hollister, and tested to evaluate the aquifer beneath a proposed damsite under construction by the Pennsylvania Gas and Water Company. The test wells were drilled 35 feet into coarse-grained glacial outwash deposits. Numerous small-diameter observation wells were installed around the test wells to allow precise measurements of the cone of depression during the tests. The results of the tests are as follows:

Well number	T ($ft^2\ day^{-1}$)	(S)	Pumping rate (gpm)	Length of test (hrs.)
Lk-390	27,000	0.3	163	45
Lk-391	2,700	.1	48	13

The results show that well Lk-390 penetrated a more permeable material than well Lk-391, although they were only 300 feet apart. The aquifer apparently thins or becomes finer grained in the direction of well Lk-391, which would limit the rate of continuous pumping of either well.

Wells similar to those described could be located in many valleys in Lackawanna County, particularly in those valleys underlain by thick unconsolidated deposits, as delineated on the geologic map (Plate 1). A well-exploration program would be necessary to locate the most permeable zones, and adequate well spacing would be necessary, owing to the small areal extent of the individual valleys. There are isolated deposits in the Lackawanna Valley that could produce small quantities of water; however, most uneonsolidated deposits overlie mines, and recharge to these deposits seeps through to the mine openings below.

Development of water supplies from the unconsolidated aquifers would be limited to that water recharged by precipitation or that induced into the aquifer from nearby streams or rivers. Wells pumped for municipal or industrial use could withdraw so much water under heavy sustained pumping that the water table would be lowered and the cone of depression would expand out to a bedrock boundary or intercept a stream, such as the Susquehanna River. Should the cone of depression extend to the Susquehanna River, river water could be induced into the aquifer. Passage through the alluvium would filter the river water and would remove suspended material, odor, taste, color, and bacteria, to a degree that should make the water suitable for many uses.

Properly constructed wells drilled in the unconsolidated aquifers along the Susquehanna River should be capable of sustained yields of 1,000 to 2,000 gpm (Hollowell, 1971, p. 32). The depth of wells along the Susquehanna, both dug and drilled, ranged from 16 to 125 feet and averaged 51 feet. In order to develop the aquifer to its ultimate capacity and in order to measure the induced recharge, a well-drilling and aquifer-testing program would logically precede installation of production wells.

Consolidated Rocks

The quantity of water that the consolidated bedrock aquifer will yield to wells depends upon the number, size, extent, width, and degree of interconnection of fractures and bedding planes; the length of that part of the well open to the aquifer; and the head of the water filling the voids. Field tests of six high-capacity wells were made to determine the range of hydraulic characteristics on or near fracture traces (see Table 2). Fractured-rock aquifers depart from the ideal conditions for which the transmissivity and storage values were derived; however, the values obtained by such tests show the relative range of magnitude of hydraulic characteristics for the fractured-rock zones in the study area. Field tests involving two or more observation wells showed that certain fractured-rock zones behave isotropically. A long-term constant-rate aquifer test of well Lk-251 was made. Water levels were observed in Lk-252 and in two wells 200 feet from the pumped well. The transmissivities computed from the drawdown data were 300 and 290 ft^2 day^{-1}, respectively. At greater distances from the axis of the fracture trace the degree of fracture interconnection decreases, and the aquifer as a whole behaves anisotropically. Fracture-trace transmissivity was generally higher than nonfracture-trace transmissivity.

Low storage coefficients, usually indicative of artesian aquifers, were obtained from nearly all tests. The average storage coefficient involving well-connected fractures was determined to be 0.0006.

WELL YIELDS

The capacity of a well to yield water is generally tested at the time the well is drilled. The reported yield values for 385 wells penetrating the consolidated rock aquifer range from less than 1 to 352 gpm. The median yield is 20 gpm (Figure 7). Few wells were reported to yield less than 1 gpm, and nearly all wells yield enough for a domestic household. The average reported yield of 287 wells drilled for household use is 22 gpm. The average reported yield of 66 wells drilled for public and institutional use is 53 gpm. The average reported yield of 32 wells drilled for commercial, industrial, recreational, and irrigational uses is 101 gpm.

Table 2. *Transmissivities and Storage Coefficients for the Catskill Formation*

Well number		Trans-missivity (sq ft/day)	Storage coefficient	Remarks
Pumped well	Observed well			
Lk-388	Lk-386	440	0.0005	
388	387	960	.0006	
281	283	920	.0001	
251	[1]	290	.0008	200 feet northeast of pumped well
251	[1]	290	.001	200 feet north of pumped well
251	252	300	.0005	2,250 feet southwest of pumped well
252	[1]	400	.0001	200 feet east of pumped well
222	221	570	.0003	
89	396	360	.0009	
89	395	260	.0002	

[1] Observation well not inventoried.

The Catskill Formation is the main aquifer in the county. Measured and reported well yields from this formation range from less than 1 to 300 gpm. The water occurs in secondary openings in the rocks, such as bedding planes, fractures, faults, and joints. The depths of wells inventoried in the Catskill ranged from 10 to 647 feet and averaged 234 feet.

The Pocono is tapped for water only locally north of Scranton. It is generally a poor aquifer. The depths of wells completed in the Pocono range from 142 to 457 feet and average 275 feet.

The rocks of Pennsylvanian age are potentially very productive aquifers, but are not tapped in most areas. The quality of water from these rocks ranges from good to bad, depending on the proximity of the withdrawal point to coal mines. Depths of wells in the Pottsville Formation range from 25 to 300 feet and average 158 feet.

SPECIFIC CAPACITIES

Specific capacity is a more accurate measure of the capability of a well to yield water than the commonly reported yield figure. The specific capacity of a well is the amount of water, in gallons per minute, that may be pumped from a well for each foot that the water level is lowered in the well. It may be used to estimate the approximate rate at which the well can be pumped for any assumed drawdown. The estimate becomes less accurate as the pumping rate is increased because the water enters the borehole with more turbulence. Turbulence is a function of the velocity of the water, the size

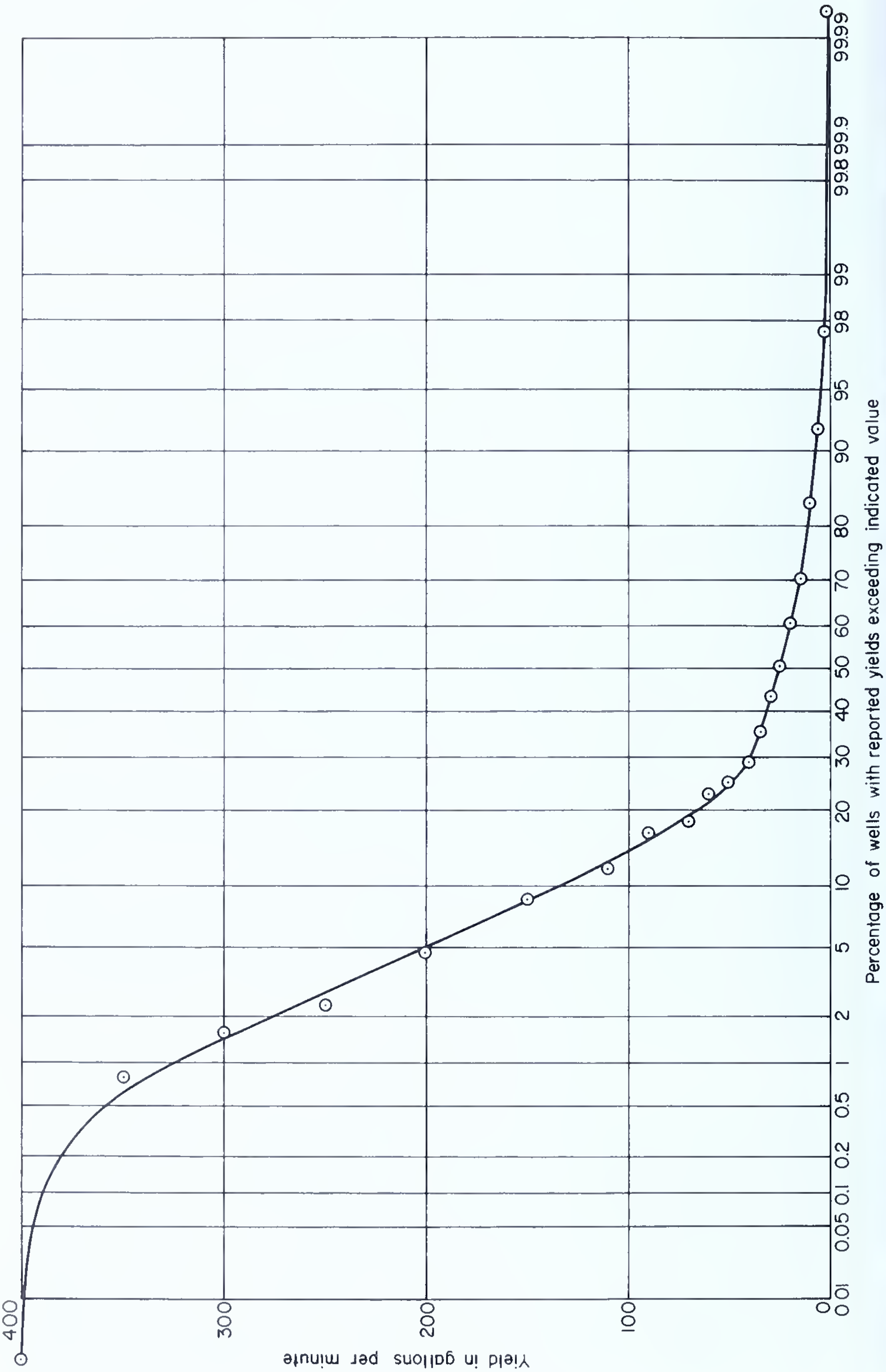


Figure 7. Cumulative-frequency distribution of reported well yields from the Catskill Formation.

of the openings in the rock around the well through which the water flows, and the diameter of the borehole.

Specific capacity decreases slowly as pumping continues. When the water level in the well declines below a yielding zone the pumping rate decreases and consequently the specific capacity is reduced.

The specific capacities calculated from 1-hour tests during this study have two shortcomings. First, a 1-hour test may not reflect the performance of a well over long periods. Second, most wells were pumped at relatively low rates, generally between 5 and 15 gpm. In the Catskill, the specific capacity of a well determined at a low pumping rate is generally substantially higher than that determined at a high rate. Because of these shortcomings, yields of wells penetrating fractured rocks cannot be computed from specific-capacity data with as much accuracy as yields of wells penetrating more homogeneous, isotropic aquifers of wide areal extent.

Specific capacities can be used to compare different lithologies, different topographic settings, or wells of different depths. Specific capacities also indicate the suitability of wells for various purposes. Wells in fractured rocks that have specific capacities of less than 0.08 are generally inadequate or barely adequate for domestic use. Wells having specific capacities of 0.5 or greater are generally suitable for small public supplies and some industries. Wells having specific capacities of 5 or greater are generally suitable for public supply and industrial use.

Specific capacities of 53 wells tested for 1 hour ranged from 0.03 to 8 gpm per foot of drawdown. The mean and median specific capacities are 1.8 and 0.65 gpm per foot of drawdown, respectively. The cumulative-frequency distribution of specific capacities is shown in Figure 8. Ninety-four percent of the specific capacities are greater than 0.08 (the minimum considered adequate for domestic wells), 60 percent are greater than 0.5, and 8 percent are greater than 5. Specific capacities computed from reported data (Figure 8) are similar to those from observed data, but slightly lower. The increasing separation of the curves with higher specific capacities is primarily due to the different methods of pumping the wells. Wells tested by U.S. Geological Survey personnel were pumped at rates less than 20 gpm. Drillers test wells at the highest rate possible, thereby causing a greater drawdown.

Specific capacities of wells grouped by topographic position show that topography influences well yield. Wells in valleys and upland waterways are higher yielding than those on hilltops and hillsides (Figure 9). The median specific capacity for wells in valleys and waterways is 1.0, on hilltops it is 0.25, and on hillsides it is 0.30. For comparison, regardless of topographic position, those wells on fracture traces have a median specific capacity of 1.8.

WELL INTERFERENCE

Where water-table conditions exist, the water level in an unpumped well will stand at nearly the same elevation as the water level in the surrounding

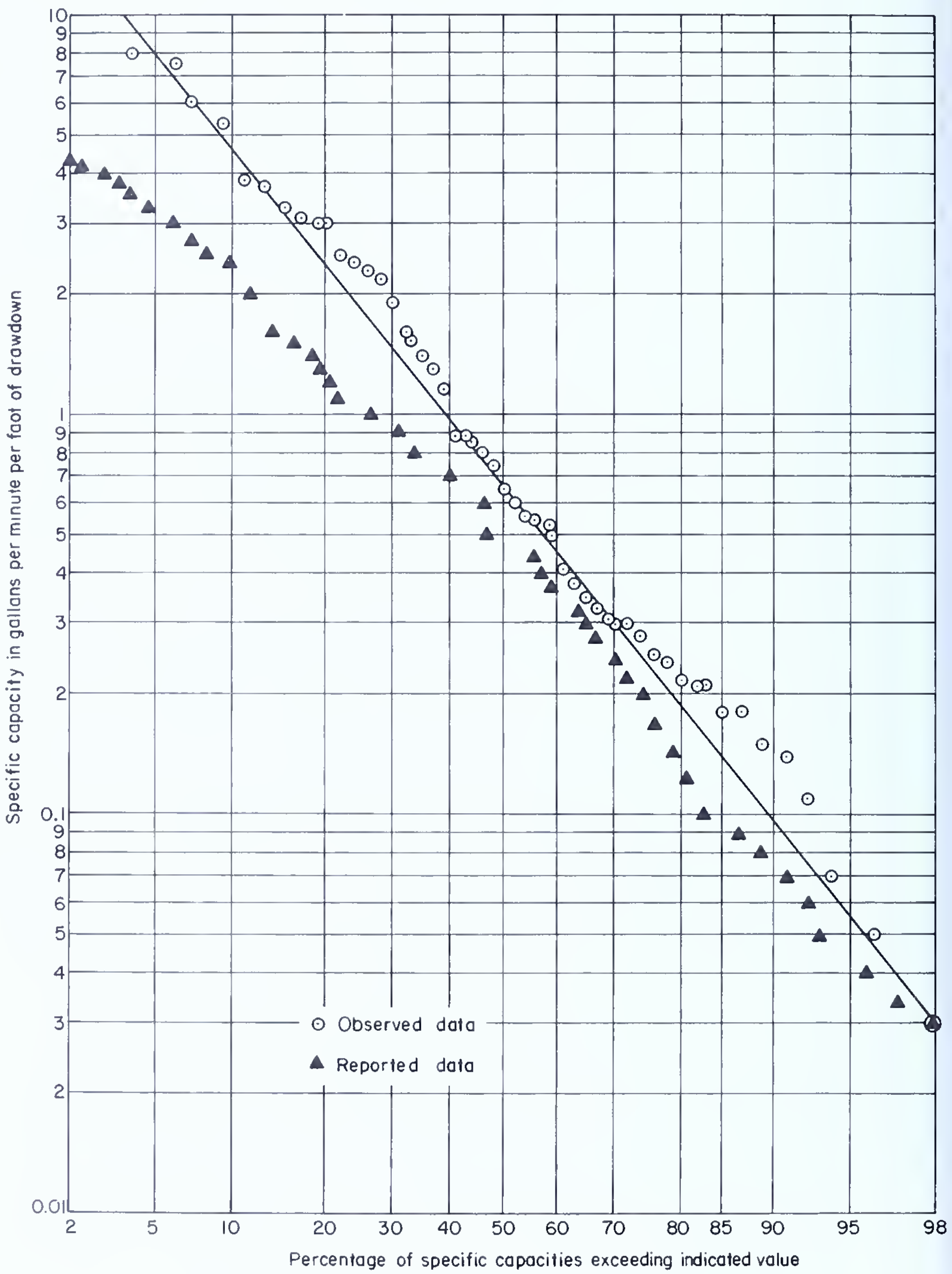


Figure 8. Cumulative-frequency distribution of specific capacity for wells pumped 1 hour.

Figure 9. Histogram of specific capacities grouped by topographic position.

aquifer. The water level inside and around a well declines as the well is pumped, and the water table surrounding the well assumes the shape of an inverted cone that has its apex at the center of the pumped well (Figure 10). This cone of depression forms as a result of an adjustment in hydrostatic pressure near the well. During pumping, the water within the aquifer moves rapidly inward and downward along and beneath the slope of the cone toward the level of the water in the well. The water level in the well drops and the cone of depression expands outward and downward until the rate at which water moves through the aquifer toward the well is virtually equal to the rate of well discharge.

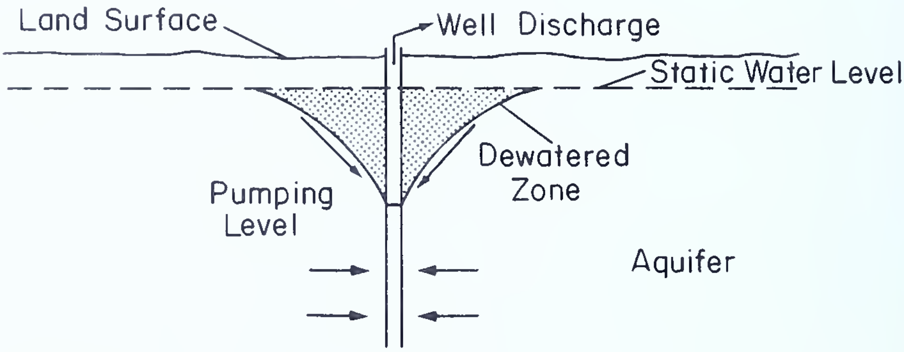


Figure 10. Section through a pumped well showing the cone of depression.

Where production wells are too close together their cones of depression overlap, causing mutual interference between wells. The interference increases the rate at which the cone of depression expands and under continued pumping may cause excessive drawdown in the pumped well, reduce pump efficiency, and reduce production. Well interference is illustrated in Figure 11 with an idealized section through two wells 2,000 feet apart and pumping 500 gpm. Part (a) shows the cones of depression after pumping for 10 minutes. Part (b) shows the cones of depression after pumping for 2 days. The dashed line represents the cones of depression if each well were outside the cone of influence of the other, and the net result is shown in part (c), which is the sum of the drawdowns at any point within the cone of depression of both wells.

From the above illustrations much can be inferred about well interference through interconnecting water-bearing zones. Withdrawal of water from wells drilled in consolidated rock aquifers and with storage in fractures shows a rapidly declining water level throughout the cone of depression and a rapidly changing shape to the cone. The cone becomes elliptical and grows in length in the direction of the fracture trace. Now if two nearby wells in a consolidated rock aquifer are drilled along the same fracture, or connected

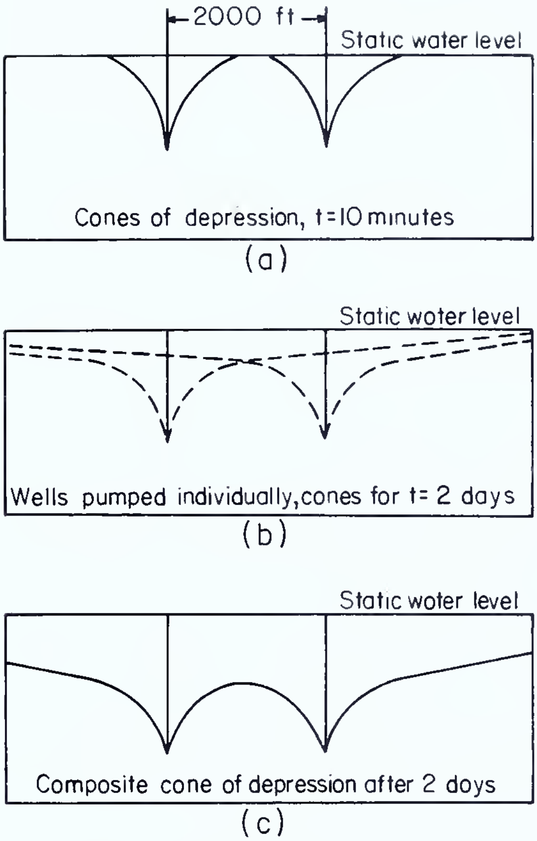


Figure 11. Section through two pumped wells showing the development of the cone of depression and the composite cone of depression for mutually interfering wells.

fractures, the pumping of one of the wells will affect the other. Wells along a line perpendicular to the strike of the water-bearing openings will be least affected. The amount of interconnection of water-bearing fractures will differ in every location, but the above relationships generally will apply.

Interference between wells penetrating the same fracture trace can be illustrated by water-level fluctuations in wells Lk-89, 232, and 225. The hydrograph for well Lk-89 (Figure 12) shows the effect of pumping a municipal well, Lk-394, 1,000 feet away. The well is pumped at the rate of 110 gpm for 8 hours and then not pumped for 16 hours, causing water-level fluctuations as large as 8 feet in the observed well. The hydrograph for well Lk-232 (Figure 13) shows the effect of pumping an irrigation well, Lk-393, 3,000 feet away. The irrigation well is pumped at a rate of 140 gpm for periods of about 18 hours a day. The drawdown in the observation well is approximately 2 inches at the end of each pumping period. Well Lk-222 was test pumped at 100 gpm for 24 hours, and the water level was drawn down 159 feet and held there for the duration of the test. Water levels were observed in well Lk-225, 1200 feet away, and at the end of the test the water level had

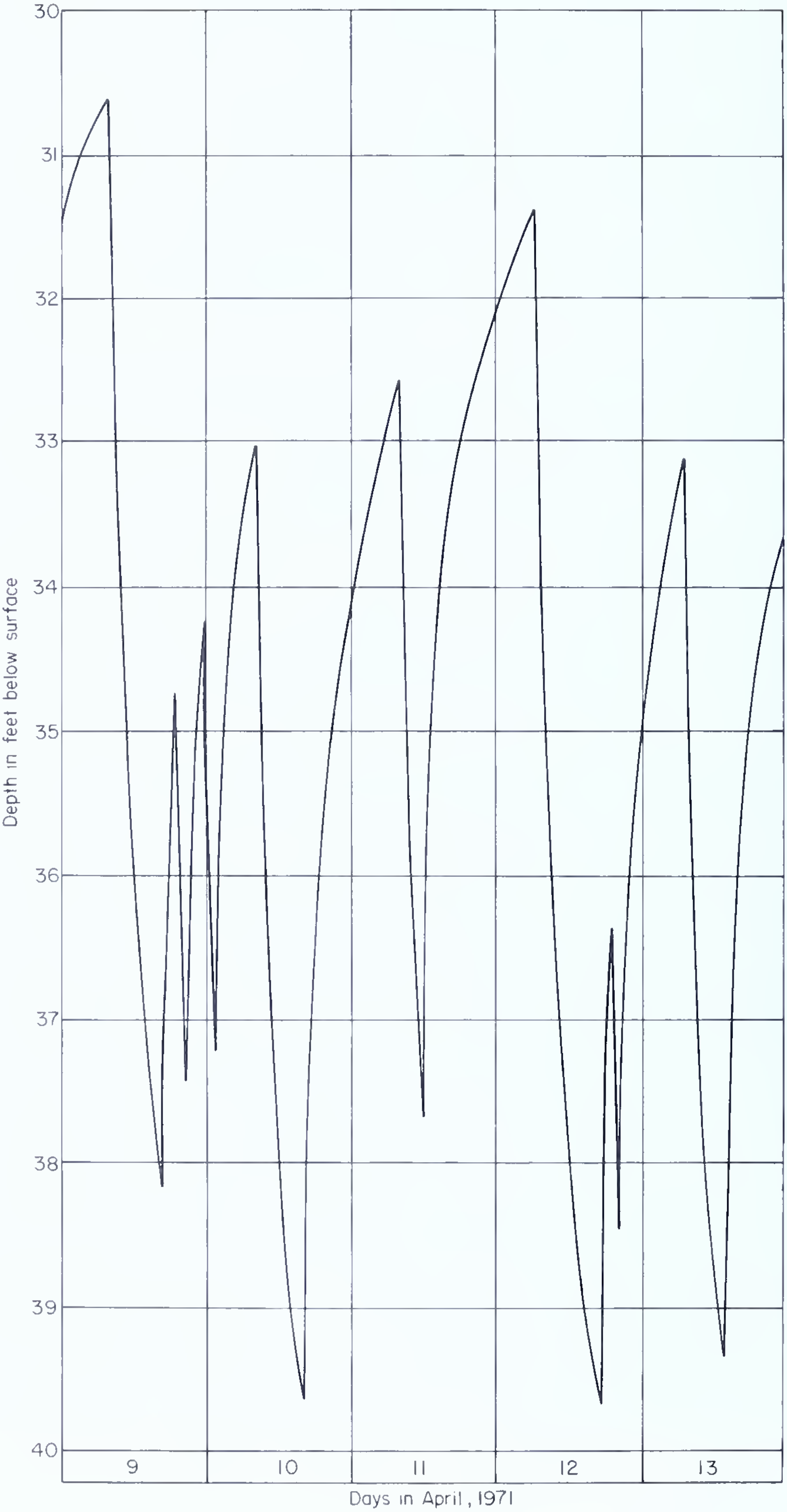


Figure 12. Hydrograph of well Lk-89 showing effect of a pumping well 1,000 feet away.

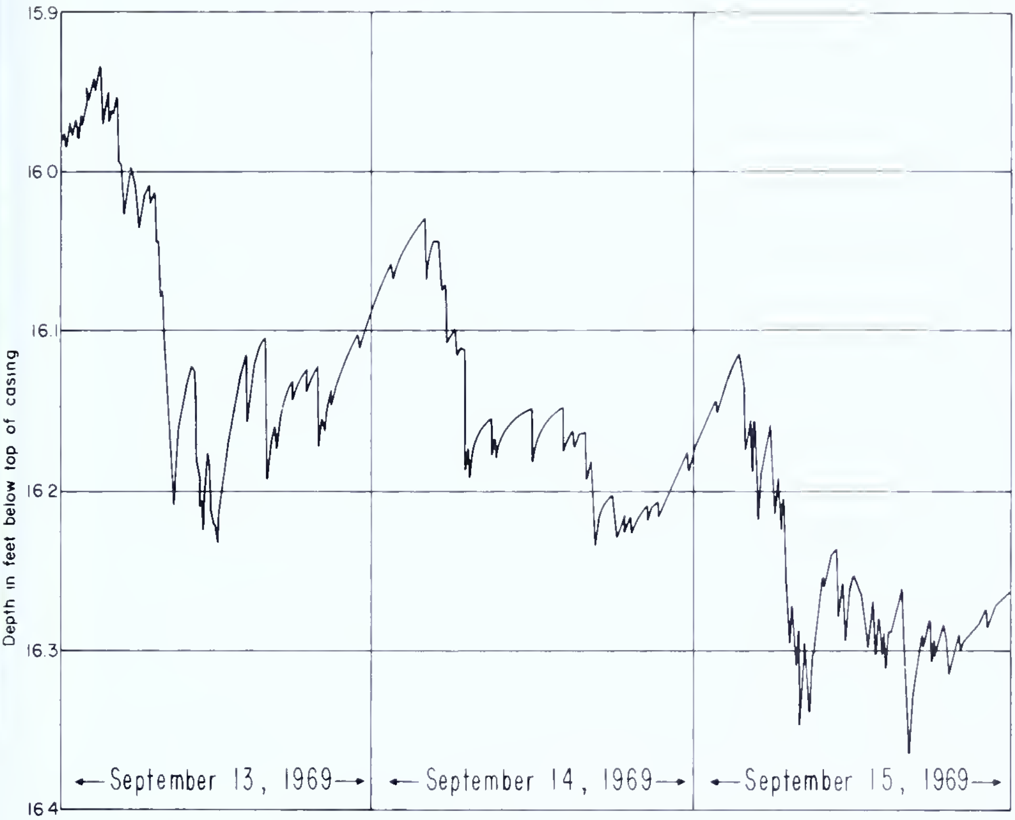


Figure 13. Hydrograph of well Lk-232 showing effect of a pumping well 3,000 feet away.

declined 11 feet. This would indicate a good connection between wells. The pumped well is located on a fracture that trends north and south (Plate 1), and the zone of fracturing probably extends to the observed well.

MINE-WATER HYDROLOGY

Water from streams infiltrates into underground workings, mainly by leakage from streambeds through broken strata overlying the mine openings. Precipitation and overland runoff enter the mines mainly through surface strippings and crevasses along steeply dipping beds where the surface has caved into voids below. From the points of entry, water flows through the mine workings to underground pools. These pools are enclosed vertically between the floor and roof of the mine openings and horizontally by barrier pillars, other unmined areas of coal, collapsed roof rock, and the bedrock structure. Barrier pillars are bodies of unmined coal that are left in each coal bed along the company property lines.

Mine practices with regard to barrier pillars varied greatly before enactment of a public law in 1891 establishing and defining the specification for barrier pillars (Ash and others, 1949, p. 9). The altitudes of the pools indicate leakage through many of the pillars.

The mine pools formed by rock structure, unmined coal, collapsed roof rock, and barrier pillars are shown in Plate 2. Water filling the mine voids forms a shoreline that is dictated by the structural limits of the bottom rock of the mined-out bed. This shoreline represents a contour on the inclined bottom rock of the mine and moves outward or inward with the rise or fall of the water surface. Most of those pools northeast of Archbald are confined by the individual basin structures, each having a mine overflow. South of Archbald, the mines form one large underground pool (Scranton pool) terminated at the downstream end by the Moosic anticline. The pool has a stairstep profile from a high near Olyphant to a low near Old Forge (see section on Plate 2). The Scranton pool overflows underground into the Old Forge mine pool, which overflows into the Central and Seneca mine pools. The Seneca pool overflows to the Lackawanna River through a back-filled stripping (most of the discharge is concentrated at one point) just downstream from Duryea in Luzerne County. A 42-inch borehole was drilled into the Old Forge mine, by the Commonwealth of Pennsylvania in September 1962, to permit gravity discharge from the pool into the Lackawanna River. This prevented the flooding of basements in the Borough of Old Forge.

Mining practices have allowed surface water to enter both active and abandoned mine workings and to accumulate in the mines. Active anthracite mines have had water problems since 1897. Abandonment of mines due to depletion of anthracite reserves caused a further burden on those operators of active mines. Once a mine is abandoned all maintenance is discontinued on all surface-water drains, flumes, and channels constructed to minimize infiltration of water into the mine. The abandoned mine then fills with water to a point where it overflows through a barrier pillar into an adjacent mine or overflows to the surface. The law prohibits mining where a high head of water exists next to the active workings. Therefore, the operator of an active mine must handle the inflow into his mine and the adjacent abandoned mine.

Since 1910 the increased pumping loads, along with decreased coal production, led to increased mine abandonment. Consequently, few underground mines in the Lackawanna Valley remained in operation by 1960. Those mines in operation pumped large volumes of water in the later years. The following table shows the total volume of water pumped to the surface by 15 major coal companies in that area now contributing to the Scranton pool.

Year	Amount pumped (gpm)	Precipitation[1] (inches)
1944	59,589	31.87
1945	83,739	53.71
1946	76,305	36.72
1947	78,715	41.46
1948	75,671	45.03

Year	Amount pumped (gpm)	Precipitation[1] (inches)
1949	71,874	35.83
1950	79,796	40.23
1951	84,208	39.21

[1] Precipitation totals from reporting station at Scranton.

Most of the water pumped from the mines was discharged into the Lackawanna River upstream from the Old Forge gaging station. This pumped water increased the base flow in the Lackawanna River, as shown by the duration curve (Figure 14) for the Old Forge gage for the 1939-59 period of record. After the mines filled with water, overflow from mines in the Scranton area bypassed the Old Forge gage underground. This is shown by the shift in the duration curve for the 1961-70 period of record. The shift was also coincident with a drought that caused a 25 percent loss in flow past the Archbald gage.

The break in the straight-line plot of the double-mass curve (Figure 15) for the Lackawanna River at Old Forge also shows the bypassing of the gage by mine water.

The rate of discharge from the Scranton pool is shown by the hydrograph (Figure 16) of the combined discharges from the Old Forge and Duryea overflows. The average discharge during 1967–70 was 48,000 gpm. The following table shows the total volume of water overflowing the Scranton pool. The overflow began in 1962.

Year	Amount of overflow (gpm)	Precipitation (inches)[1]
1962	136,000	29.69
1963	438,300	26.45
1964	482,400	22.96
1965	345,500	25.95
1966	406,100	28.19
1967	561,200	29.88
1968	597,500	35.90
1969	546,600	32.08
1970	598,200	28.01

[1] Precipitation totals from reporting station in Scranton.

The increase in discharge from approximately the same area is due to the same lack of surface-drainage maintenance over abandoned mines that plagued mine operators. Also, after the mines were abandoned, the surface

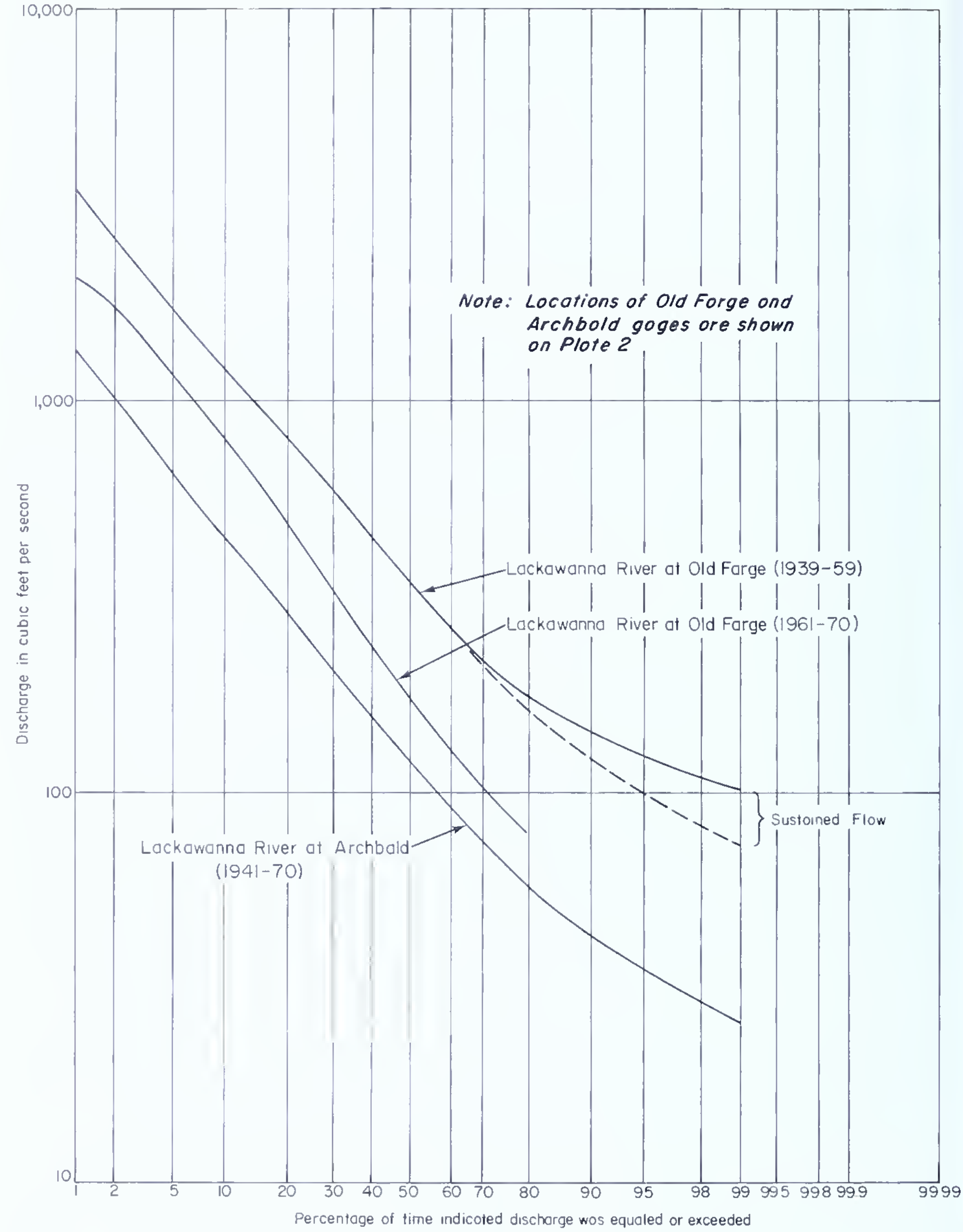


Figure 14. Flow-duration curves of daily discharge for the Lackawanna River (adjusted to 1941-70 base period).

was further disturbed by stripping, resulting in complete diversion of streams into the underground mines.

Discharges from those pools northeast of Archbald (Plate 2) were measured periodically and are tabulated in the following table.

Nearest town	Date of measurement and discharge (gpm)		
	September 1963	April 1969	November 1969
Forest City	104	4,800	Blocked
Simpson (shaft)	1,820	7,200	2,000
(drift)	906	1,350	700
Peckville	1,960	10,000	1,900
Jermyn	4,370	18,000	Covered[1]

[1] Discharged directly into the Lackawanna River below stream level.

Recharge to the underground mines occurs mainly through streamflow loss through broken and stripped ground that the stream traverses. Streamflow data in Table 3, collected by W. T. Stuart, formerly of the U.S. Geological Survey, shows streamflow loss in creeks that flow into the Lackawanna River. The data in the table show that all the streams, in some reaches, are losing water through the stream channel to the mines below.

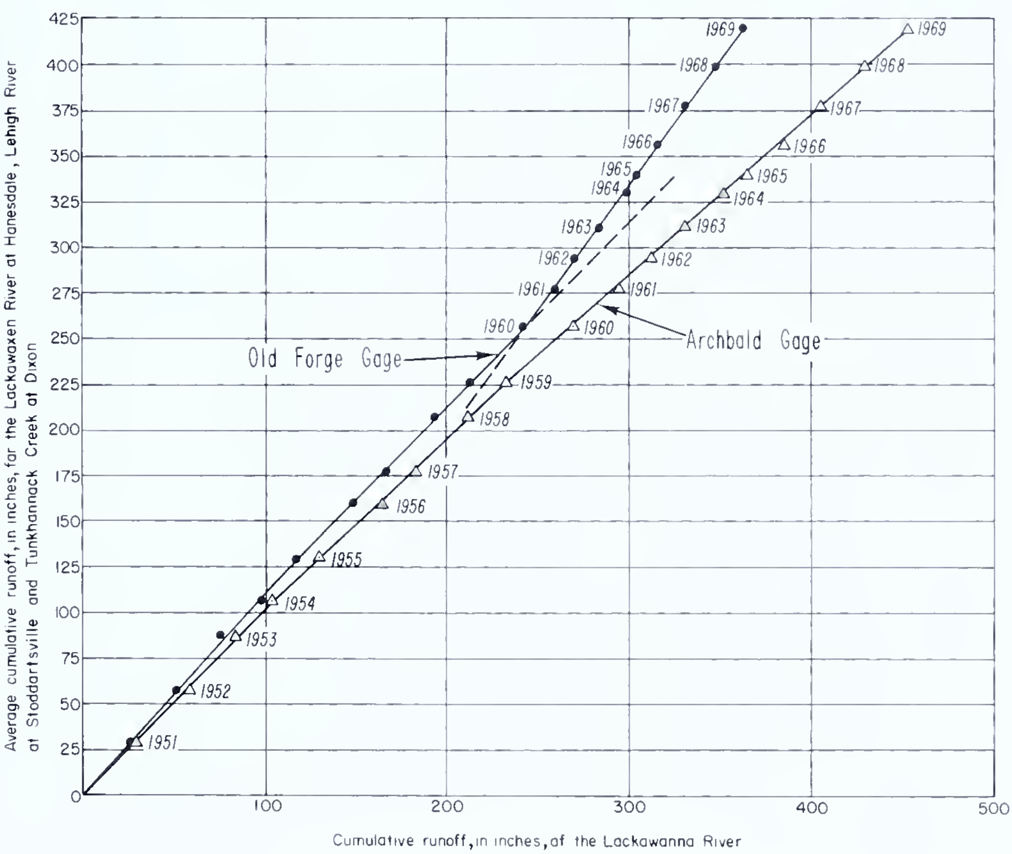


Figure 15. Double-mass plot of cumulative discharge of the Lackawanna River versus cumulative runoff of three nearby streams, 1951-69.

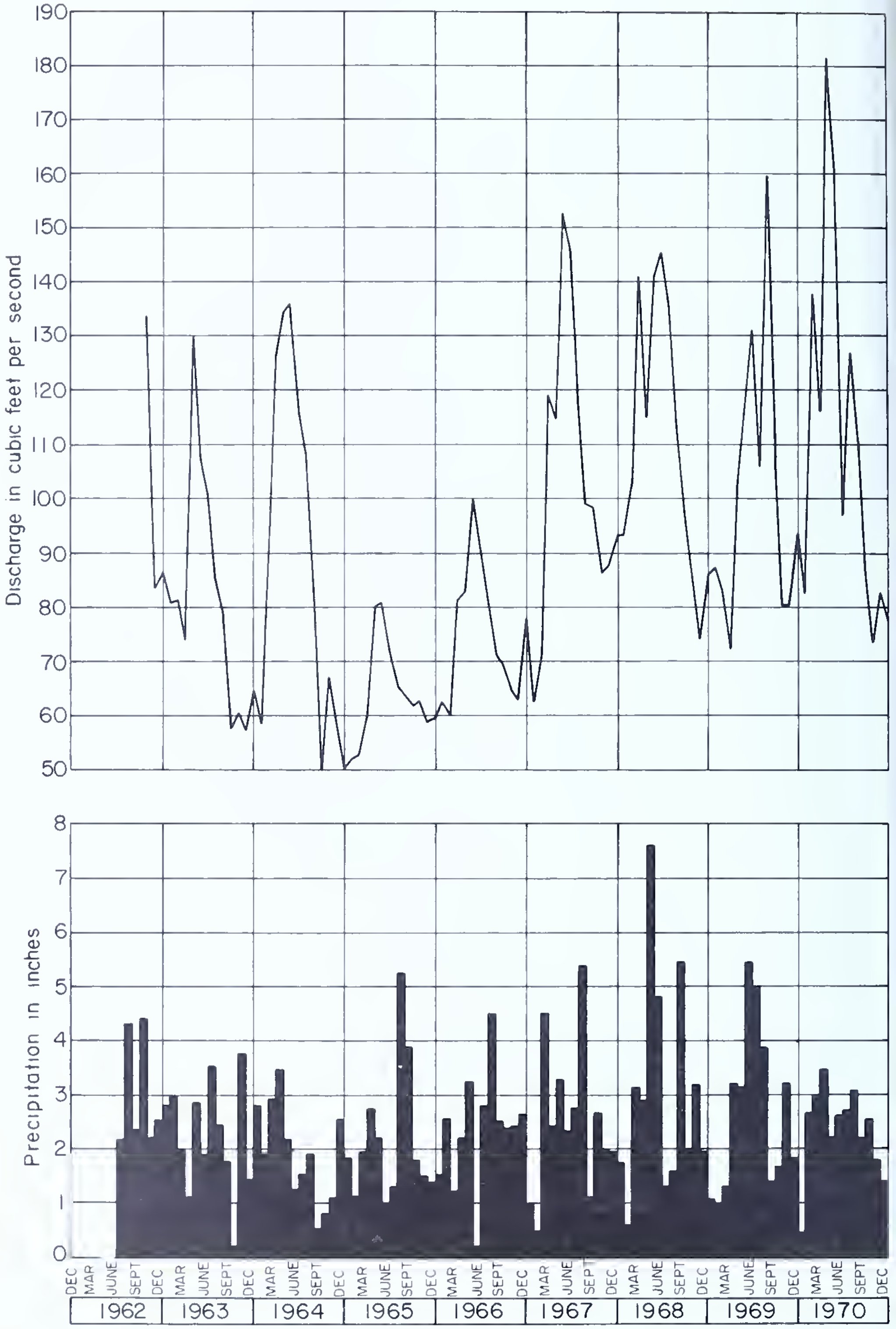


Figure 16. Hydrograph of mine-water discharge from Scranton pools and monthly precipitation totals at Scranton.

Table 3. *Streamflow Loss from Eight Creeks that Flow into the Lackawanna Valley, 1956*

Name of creek	Station number shown on Plate 2	Distance from outcrop of lowest mined coal bed (feet)	Flow (gpm)		
				Oct. 17	Nov. 30
	268	1,000 above		235	660
Hull	269	1,700 below		267	744
	270	4,200 below		17	585
	271	6,800 below		0	505
				Oct. 11	Nov. 27
	262	4,000 above		283	1,291
Grassy Island	263	1,400 above		356	1,694
	264	300 below		426	1,629
	265	4,600 below		153	1,197
			May 22	Aug. 8	Nov. 20
	82	2,000 above	524	62	198
Sterry	83	800 above	—	102	355
	84	1,600 below	934	17	306
	85	3,400 below	1,069	25	402
					Oct. 8
	246	1,600 above			2,687
Leggets	247	3,400 below			2,965
	248	10,000 below			2,770
					Oct. 17
	250	200 below			171
Leach	251	1,000 below			191
	252	3,000 below			183
	253	7,000 below			138
				Oct. 9	
	255	200 above		21	
Nassau	256	2,000 below		11	
	257	3,700 below		18	
				Apr. 7	Aug. 16
	108	100 above		1,510	57
	109	700 below		1,332	82
Lindy	110	1,400 below		1,529	59
	111	3,700 below		1,422	40
	112	5,500 below		1,335	21
					Mar. 13
	115	6,600 below			1,004
St. Johns	117	10,600 below			827
	118	12,800 below			1,105[a]

(Continued)

Table 3. *(Continued)*

Name of creek	Station number shown on Plate 2	Distance from outcrop of lowest mined coal bed (feet)	Flow (gpm)
	119	17,600 below	1,015
St. Johns	120	18,200 below	877
	121	22,200 below	915

[a] Tributary confluence.

Most of the streams lost flow with each succeeding downstream measurement below the outcrop area of the lowest mined coal bed. The amount of loss depends on the extent of the ground breakage and mining conditions, as reflected by the different amounts of stream loss and the absence of any loss in a few reaches. All the flow of Eddy Creek enters the mines through a backfilled stripped area.

A solution for reducing mine-water pollution of streams would be the complete restoration of the surface to establish overland runoff. Complete restoration, of course, would be very expensive, but infiltration could possibly be reduced 50 percent by restoring only the stream channels. When the underground mines were operating, the coal companies maintained the stream channels crossing their property to prevent the sudden influx of water from storm runoff. A Federal-State mine-water-control program for the Anthracite region was begun in 1955 to help the coal industry control mine water. Numerous projects were completed under the act to restore surface drainage and to flume overland runoff across broken ground and strip pits. At the time these projects were approved, the reduction in pumping load by stream-channel improvement was about 10 percent (Dierks and others, 1962, p. 15). This reduction was accomplished in addition to maintenance already begun by the coal companies. Now that underground mining has ceased, stream channels are not maintained, and subsequent strip mining has destroyed or reduced the effectiveness of past stream improvement.

WATER QUALITY

GEOCHEMICAL CYCLE

The percentage of combined chemical constituents found in water in various parts of the hydrologic cycle of Lackawanna County are represented in Figure 17 by pie diagrams. The chemical constituents were derived from the atmosphere (chiefly oxygen, carbon dioxide, nitrate, and chloride),

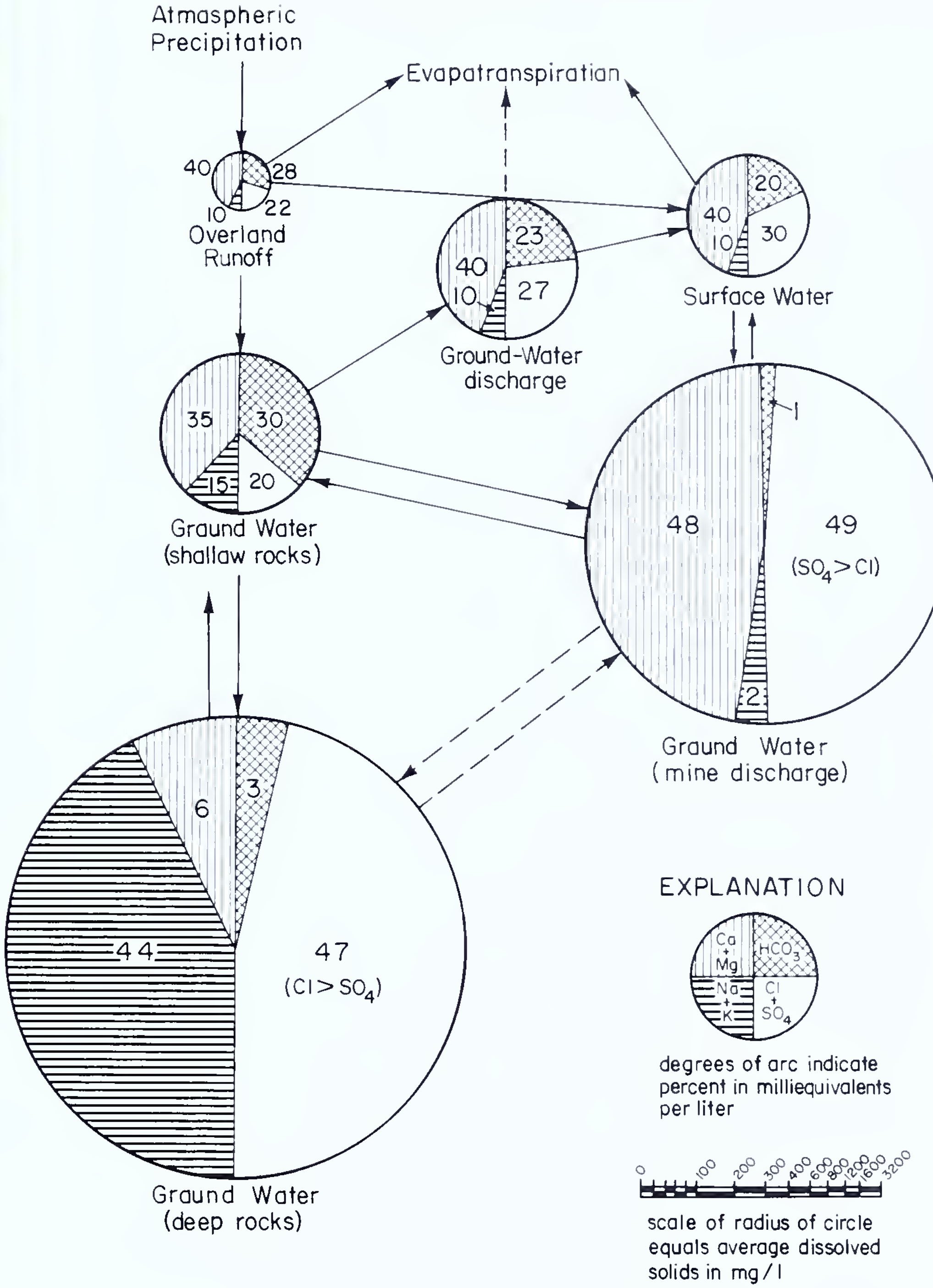


Figure 17. Geochemistry of the water cycle in Lackawanna County.

from weathered rocks (carbon dioxide, carbonate, sulfuric acid, sulfate, and chloride), and from the decaying remains of organisms (nitric acid, nitrate, ammonia, carbon dioxide, and humic complexes). Surface runoff contains

a high percentage of gases from the atmosphere, such as carbon dioxide and a minor amount of sulfur dioxide given off by the burning culm banks in the valley. Surface runoff and precipitation dissolve salts from the soil mantle. More soluble minerals are taken into solution as the water circulates through the rocks. The amounts and characteristics of these dissolved minerals are influenced largely by the composition of formations contacted by the water, the duration of contact, and the chemical character of the infiltrating water. Generally, water in deep aquifers circulates over a longer distance than that in shallow aquifers. The water-retention time at depth is longer, and water in deep rocks becomes more highly mineralized. Dissolved-solids content in ground water measured during this study ranges from 25 to 1,210 mg/l (milligrams per liter).

Table 4 is a comparison of the chemical character of water from various sources in Lackawanna County. Water from more than 80 percent of bedrock wells, 90 percent of springs and wells in unconsolidated materials, and 70 percent of the surface water is of the calcium bicarbonate type. Only 5 percent of the bedrock well water is of the sodium chloride type, and 7 percent is of the sodium bicarbonate type. Surface water having sulfate concentrations greater than 250 mg/l is contaminated by mine drainage.

The high dissolved-solids content of the ground water does not follow any distinct pattern, although the content is greater in the valleys and lesser generally south of the Lackawanna Valley and in sandstone beds of the Pocono Formation, particularly around Bald and West Mountains. Few distinct patterns of similarity of ground-water quality exist on the plateau; however, ground water in the outcrop areas is low in dissolved solids, ranging between 100 and 200 mg/l. Ground water with a dissolved-solids content of less than 100 mg/l occurs along sandstone outcrops and in unconsolidated materials.

The electrical conductance of streams was measured at various locations to determine the aerial distribution of dissolved solids (Plate 3). The conductances were measured during low-flow periods, when water in the streams was most representative of ground-water discharge. Mine-water discharges have a great influence on the conductance of water along reaches of the Lackawanna River and tributaries, as they add high concentrations of calcium, magnesium, iron, and sulfate.

Recharge to ground-water reservoirs from surface-water bodies may influence, in part, the zonal distribution of ground-water quality within the plateau. Much of the plateau uplands are covered with marshes, swamps, and peat bogs that contain water with a pH between 5 and 6, owing to the abundance of organic acid. Water from these environments that recharges aquifers dissolves sulfide from the rocks and adds hydrogen sulfide and metal carbonates to the ground water. In much of the plateau area north of the valley, acidic water recharging the aquifer may be neutralized by abundant calcareous materials in the rocks.

Table 4. *Percentage Distribution of Various Chemical Types of Water*

Source	Number of samples	Percent calcium bicarbonate type ($Ca(HCO_3)_2$)	Percent sodium chloride type ($NaCl$)	Percent exceeding: 250 mg/l Chloride (Cl)	Percent exceeding: 250 mg/l Sulfate (SO_4)	Percent exceeding: 100 mg/l dissolved solids	Percent exceeding: 500 mg/l dissolved solids
Bedrock wells (deep and shallow)	130	83 [a]	5 [a]	2	0	85	3
Unconsolidated wells and springs	25	92	0	0	0	8	0
Surface waters	28 [b]	68	0	0	14	21	7
Deep-mine discharges	11	0	0	0	45	100	36

[a] Other types include:
Sodium bicarbonate ($NaHCO_3$), 7 percent
Calcium sulfate ($CaSO_4$), 2 percent
Ferrous bicarbonate ($Fe(HCO_3)_2$), 2 percent
Ferrous sulfate ($FeSO_4$), 1 percent
Calcium chloride ($CaCl_2$), 1 percent

[b] Includes several samples of overland runoff.

Under reducing conditions in carbonate-poor areas, an organic complex could decompose to form methane. Minor amounts of methane have been found in a flowing well (Lk-150) in Benton Valley, an area of highly fractured rock. The well is 175 feet deep and is open in the Catskill Formation. An analysis of the gas, collected on November 14, 1968, and analyzed by the U.S. Bureau of Mines, is as follows:

Gas	Percent
Methane	67.7
Propane	Trace
Nitrogen	31.6
Argon	.4
Hydrogen	Trace
Carbon dioxide	Trace
Helium	.25
Total	100

Calculated BTU per ft^3: 685
Specific gravity: 0.687 (sp. gr. of methane is 0.554)

CHEMICAL CHARACTER OF SURFACE WATER

Water in most streams on the plateau is low in dissolved solids and generally is of good to excellent quality. Dissolved solids range from less than 50 mg/l in most streams south of the valley to between 50 and 100 mg/l in most streams north of the valley (Plate 3).

Water in streams that drain the plateau is of the calcium and magnesium bicarbonate types where the drainage area is entirely within the Catskill Formation. Some tributary streams and most of the mainstem of the Lackawanna River that flow over Pennsylvanian coal-bearing formations are higher in sulfate and the water contains both bicarbonate and sulfate or only sulfate as major anions.

The chemical character of the streams is influenced by the discharge rate. Runoff moving rapidly over the ground to the stream picks up relatively small amounts of dissolved materials and generally reduces mineralization of water in the stream. Low-flow sampling and discharge-measurement sites are shown in Plate 3. Chemical analyses of stream samples are shown graphically in Plate 3 and are presented in Table 5. An attempt was made to collect these data during base-flow conditions in order to illustrate the quality, quantity, and availability of ground-water discharge. The surface-water map and table provide a basis for inference of these hydrologic parameters, although mines in the Valley have altered the quality and quantity of discharge to the surface channel.

Samples of mine water were collected for analysis during periods of high and low pool level (Tables 6 and 7) at most major overflow points (Plate 3).

Table 5. *Chemical Analyses of Water from 16 Streams Sampled During Low Flow*

Station number[1]	Discharge (cfs)	Dissolved solids: Concentrations (mg/l)	Dissolved solids: Loads (tons per day)	Total hardness (mg/l)	Chloride (mg/l)	Alkalinity as bicarbonate (mg/l)	Percent alkali metals	Percent alkalinity	Conductance (micromhos)
1	23	44	3.0	26	1.8	23	15	64	62
2	11	62	1.84	41	2.2	16	8	30	100
3	1.8	50	.24	21	2.5	9	24	22	73
4	163	205	90.2	142	2.9	24	5	12	317
5	3.4	96	.88	57	8.9	45	27	47	162
6	2.0	477	2.58	341	3.5	0	2	0	831
7	4.7	43	.55	26	2.4	12	16	32	65
8	323	566	494	415	6.2	18	6	3	852
9	8.2	81	1.79	62	2.1	10	4	12	127
10	6.4	963	16.6	668	7.8	18	5	2	1,200
11	4.6	102	.87	69	3.4	65	16	65	167
12	3.7	87	1.27	61	4.0	49	13	57	146
13	56	55	10.2	37	2.6	34	12	64	91
14	34	61	42.7	42	2.5	36	10	63	98
15	120	27	8.75	21	1.0	17	7	65	32
16	1,215	153	502	136	13	108	18	66	277

[1] Location shown on Plate 3.

Table 6. *Chemical Analyses of Water Overflowing Six Mine Pools in the Lackawanna Valley During High Pool Level, April 16-22, 1969*

(Concentrations in milligrams per liter, except as indicated)

Constituent	Forest City	Simpson shaft overflow	Jermyn	Gravity slope	Old Forge	Duryea
Discharge (gpm)	4,800	1,350	18,000	10,000	26,000	21,000
Temperature (°C)	7.7	9.7	10.0	8.9	14.0	15.0
Conductance (micromhos at 25°C)	197	454	637	455	1,770	1,870
Field pH	4.72	5.45	3.68	4.73	4.75	5.32
pH (oxidized and boiled)	5.4	7.1	3.7	4.3	2.5	3.0
Aluminum (Al)	—	.3	1.2	1.6	—	—
Iron (Fe^{+2})	.00	.07	2.7	.87	—	104
Total iron	.17	.18	5.6	1.3	88	104
Manganese (Mn)	—	.62	3.3	2.2	—	—
Sodium (Na)	7.0	17	—	—	—	—
Hydrogen (H)	.7	.0	1.2	.9	3.2	5.8
Bicarbonate (HCO_3)	3	23	0	4	0	0
Sulfate (SO_4)	74	196	284	211	1,250	1,300
Chloride (Cl)	21	5.4	6.2	3.6	13	14
Nitrate (NO_3)	.6	.5	.8	.2	.1	.0
Hardness						
Total	72	216	256	212	985	935
Noncarbonate	70	197	256	208	985	935
Dissolved solids (residue on evaporation at 180°C)	162	340	456	329	1,860	1,900
Dissolved oxygen (D.O.)	5.3	9.2	3.7	4.0	—	.0
Hydrogen sulfide (H_2S)	—	—	<1.0	.0	—	—

Table 7. *Chemical Analyses of Water Overflowing Four Mine Pools in the Lackawanna Valley During Low Pool Level, October 30, 1969*

(Concentrations in milligrams per liter, except as indicated)

Constituent	Simpson upper drift	Simpson shaft overflow	Gravity slope	Old Forge borehole
Discharge (cfs)	700	2,000	1,900	18,000
Temperature (°C)	9.8	9.8	9.7	15.9
Conductance (micromhos at 25°C)	470	437	605	1,690
Field pH	6.4	5.9	5.0	4.9
pH (oxidized and boiled)	3.35	3.05	2.75	2.55
Silica (SiO_2)	6.2	7.1	11	15
Aluminum (Al)	.0	.2	5.6	.3
Iron, total (Fe)	1.9	.17	.12	98
Manganese (Mn)	.60	.53	3.7	11
Nickel (Ni)	.05	.10	.26	.24
Copper (Cu)	.01	.00	.05	.01
Zinc (Zn)	.08	.30	.67	.22
Calcium (Ca)	45	41	56	196
Magnesium (Mg)	25	26	32	120
Sodium (Na)	2.0	2.5	4.2	17
Potassium (K)	1.6	1.6	2.0	4.0
Hydrogen (H)	.5	.9	1.8	2.8
Sulfate (SO_4)	230	219	364	1,260
Chloride (Cl)	3.1	4.5	3.0	2.5
Fluoride (F)	.2	.3	.4	1.9
Nitrate (NO_3)	.4	.2	.6	8.2
Hardness (total)	216	210	271	982
Dissolved solids (residue on evaporation at 180°C)	349	338	501	1,870

The free sulfuric acid and metallic ions in these overflows are not a major pollution problem to the Lackawanna River above Jermyn. Most mines draining directly into the Lackawanna River below Jermyn contain free sulfuric acid and high concentrations of iron, aluminum, and manganese. Dissolved-solids content below the Lackawanna River at Old Forge ranges from 95 to 1,280 mg/l. The total load of dissolved solids from mine overflows ranges from 300 to 1,700 tons per day and averages more than 1,000 tons per day.

Table 8 gives the extremes and means for the major constituents during the period of record for the Lackawanna River at Archbald and Old Forge.

The specific-conductance frequency-distribution curve for the Lackawanna River at Old Forge for 1948 to 1951 shows that the specific conductance was 980 micromhos (dissolved-solids content is approximately 735 mg/l)

Table 8. *Chemical Analyses of Water Sampled at Archbald and Old Forge Gages on the Lackawanna River for Maximum, Minimum, and Mean Stages, Water Years 1944-70*

	Daily discharge (cfs)	Silica (SiO_3)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Hardness as $CaCO_3$: Total calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Acidity (H^+)	Specific conductance (micromhos at 25°C)	pH	Dissolved solids
1-5345. Lackawanna River at Archbald																	
Maximum	9,510	19	7.1	5.4	2.9	51	47	14	297	10	8.2	320	320	4.6	691	7.2	518
Minimum	13	4.4	.0	.00	.00	12	7.2	9	9.0	.5	.0	61	54	.2	157	3.4	115
Mean	194	8.2	1.9	2.6	1.1	24	18	3	135	5.3	2.1	139	137	.8	243	5.1	242
Number of analyses	—	33	17	18	17	48	48	66	69	70	68	68	68	19	71	70	51
1–5360. Lackawanna River at Old Forge																	
Maximum	31,000	24	23	24	4.0	148	96	163	858	54	25	884	884	74	1,560	7.1	1,280
Minimum	20	3.6	.0	.00	.00	12	5.0	0	10	1.4	.0	4	0	.1	57	2.8	95
Mean	501	10	5.6	5.7	.78	54	36	7	317	9.0	2.7	303	299	1.6	694	4.3	505
Number of analyses	—	127	94	18	18	142	141	201	280	278	278	277	277	150	282	282	148

or more for 50 percent of the time (Figure 18). However, the curve for the years 1964 to 1970 shows the specific conductance to be 300 micromhos (210 mg/l) or more for 50 percent of the time.

The difference in the area below the curves (Figure 18) is due to the water flowing through the mines and bypassing the gaging and sampling site at Old Forge.

Suspended-sediment yield was measured on Tunkhannock Creek and the Lackawanna River during 1967. The yields for the Tunkhannock Creek and Lackawanna River basins are 103 and 591 tons per day, respectively. The basins are similar in size, topography, and forest cover. However, strip mining, spoil banks, culm banks, and abandoned siltation basins in the Lackawanna Valley provide a source of fine sediments.

Other pollutants in surface water are the direct result of waste-water disposal. Most of the industry and municipal sewage systems discharge wastes directly into bodies of surface water. Some sewage has little or no treatment before release. The wastes include raw sewage, syndets, chloride, nitrate, sulfate, and free hydrogen ions. Sewage-treatment plants and sanitary sewers are being constructed throughout the Lackawanna Valley.

Trace Metals

Recent (1971) findings of relatively high levels of zinc and cadmium and occasionally high lead and cobalt in reservoirs of public water supply and in rivers and streams of the anthracite region (Durum and others, 1971) emphasize the complexity of the natural water chemistry. Although most trace metals in Lackawanna County are thinly but widely spread in nature, certain environments contain significantly high concentrations. High concentrations of trace metals are likely to be found in black shale, coal, lignite, and peat bogs. Trace-metal analyses of water discharging from coal mines and peat bogs and of waste water used in extinguishing burning culm piles have been obtained.

Mine-Water Outfalls

Samples collected from mine overflows were analyzed and listed in Tables 9 and 10.

The extremely water soluble trace elements, such as boron, lithium, and rubidium, are more abundant in the mine water of the Lackawanna coal basin than in mine water in other parts of Pennsylvania. Lithium in water from the Lackawanna coal basin ranges from 26 to 150 $\mu g/l$ (micrograms per liter). Trace elements that form relatively insoluble sulfates such as barium and strontium have a narrow range of concentrations, but the more soluble strontium may have a high concentration in more dilute mine waters. Reducing or extremely acidic conditions are required to release insoluble oxides or hydroxides from the aluminosilicate rocks. In the lower part of

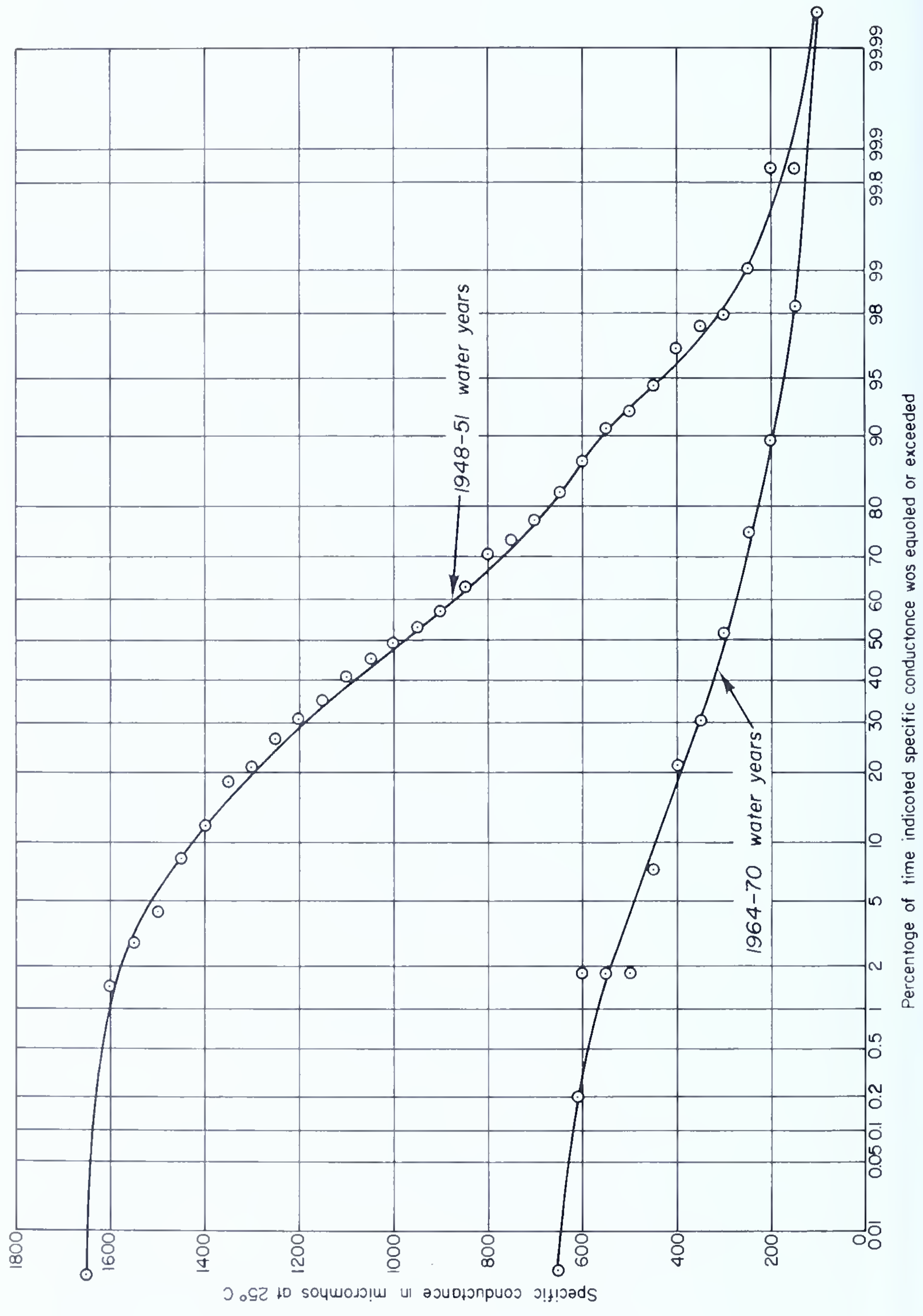


Figure 18. Relation of specific conductance to discharge of the Lackawanna River at Old Forge.

Table 9. *Trace-Metal Analyses of Water Overflowing Three Mine Pools in the Lackawanna Valley, October 30, 1969*

(Locations shown on Plate 2)

(Concentrations in milligrams per liter)

Constituent	Simpson upper drift	Simpson shaft overflow	Gravity slope Archbald	Old Forge borehole
Aluminum (Al)	0.03	0.17	5.6	0.32
Barium (Ba)	.02	.02	.02	.03
Beryllium (Be)	<.001	.001	.01	<.006
Bismuth (Bi)	<.006	<.005	<.008	<.030
Boron (B)	.03	.03	.04	.09
Cadmium (Cd)	<.055	<.050	<.080	<.060
Chromium (Cr)	<.006	<.005	<.008	<.030
Cobalt (Co)	<.010	.018	.12	.26
Copper (Cu)	.002	.004	.04	.001
Germanium (Ge)	<.006	<.005	<.008	<.030
Iron (Fe)	1.7	.15	.11	>56
Lead (Pb)	.006	.006	.02	<.030
Lithium (Li)	.02	.03	.04	.15
Manganese (Mn)	.65	.58	3.6	12
Molybdenum (Mo)	<.001	<.001	<.002	<.006
Nickel (Ni)	.04	.08	.16	.37
Rubidium (Rb)	.003	.004	.005	.02
Silver (Ag)	<.0006	<.0005	<.0008	<.003
Strontium (Sr)	.25	.17	.31	1.9
Tin (Sn)	<.006	<.005	<.008	<.030
Titanium (Ti)	<.006	<.005	<.008	<.030
Vanadium (V)	<.006	<.005	<.008	<.030
Zinc (Zn)	<.520	.14	.51	.13
Dissolved solids (residue on evaporation at 180°C)	349	338	501	1,870

the Lackawanna basin, concentrations of molybdenum and vanadium are higher than in water from the bituminous coal fields. Concentrations of beryllium, chromium, titanium, and zirconium are less than those in the bituminous areas.

The trace metals that form relatively soluble sulfides in an acid medium are cobalt, nickel, and zinc. Cobalt and nickel are relatively abundant in most mine water of Lackawanna County and range in concentration from less than 10 to 260 μg/l, and from 40 to 370 μg/l, respectively. The cobalt-to-nickel ratio is highest in water of the anthracite fields, where it is 3:5 compared with 2:5 in the bituminous fields. The ratio in all Appalachian coals is approximately 1:4. The higher ratio probably reflects the increased

Table 10. *Trace-Metal Analyses of Water Overflowing Three Mine Pools in the Lackawanna Valley, April 8, 1971*

(Analyses by atomic absorption, results in micrograms per liter, except as indicated)

Constituent	Simpson drift	Archbald gravity slope	Old Forge borehole
Specific conductance (micromhos)	455	495	1,500
Temperature (°C)	9.7	9.5	15.2
pH	6.5	5.7	5.1
Iron (Fe)	200	680	66,000
Manganese (Mn)	170	1,900	8,000
Cadmium (Cd)	0	2	3
Chromium (Cr)	0	0	0
Cobalt (Co)	0	100	170
Copper (Cu)	0	12	3
Lead (Pb)	10	0	20
Nickel (Ni)	0	120	230
Strontium (Sr)	230	280	1,800
Zinc (Zn)	8	94	22

cobaltous ion activity under reducing conditions and the more stable activity of nickel under all conditions. Zinc compounds are easily dissolved in acid water, but only low concentrations are present in the anthracite area. Zinc concentrations in mine water of Lackawanna County range from 130 to 510 $\mu g/l$.

The insoluble sulfides, even in acid media, make up the largest group of trace metals and are of greatest concern because of their great toxicity in water. The concentrations of these metals ordinarily are much greater in bituminous than in anthracite mine drainage. The trace metals in this group include bismuth, cadmium, copper, germanium, lead, mercury, silver, and tin. The mercuric ion (Hg^{+2}) forms the most insoluble sulfide in this group, and, for this reason, it is not usually found in mine waters. The plumbous ion (Pb^{+2}) is the only ion in this group that forms an insoluble sulfate as well as an insoluble sulfide; this explains its near absence in mine water. The concentrations of lead are slightly higher in mine water from northern anthracite fields than in water from the bituminous fields. Both cadmium and copper ions form soluble complexes and occasionally occur in high concentrations.

Peat-Bog Discharges

Although ordinarily not serious, water has been contaminated by flow from peat bogs. Tea-colored bog water has a low pH from organic acids, and any sudden release of acids may enhance the complexing of metals in a receiving stream, particularly during low flow.

Changes in chemical properties of bog water are caused by precipitation and fluctuations in the ground-water level. Total mineralization in bog water is low, and the water is soft. The analyses presented in Table 11 represent discharge from a bog during low and high ground-water-table conditions for July 1970 and for April 1971, respectively. The bog sampled is in the southern part of the county (Plate 3).

An open pond to the south of Roaring Brook Estates receives water from another peat bog in the same general area described above. Water from the pond, sampled March 5, 1970, contained 0.51 mg/l of manganese and 0.22 mg/l of iron, and water from nearby spring Lk-Sp 3, located on a fracture zone (Plate 1), contained 0.50 mg/l and 2.2 mg/l of manganese and iron, respectively. A manganese oxide deposit can be seen in the stream below the pond, particularly around supports for a metal bridge and pipe conduits in the water. Reducing conditions at the bottom of the peat bog and organic complexing from particulate organic debris and decaying plants may be the source of these elements.

Table 11. *Trace-Metal Analyses of Water Overflowing a Peat Bog*

(Analyses by atomic absorption, results in micrograms per liter, except as indicated)

Constituent	Low ground-water table	High ground-water table (filtered)	(unfiltered)
Date	7-7-70	4-8-71	4-8-71
Specific conductance (micromhos)	33	<50	<50
Temperature (°C)	15.3	4.5	4.5
pH	5.7	5.2	5.2
Aluminum (Al)	—	—	560
Iron (Fe)	1,200	180	180
Manganese (Mn)	120	100	60
Calcium (Ca)	—	7,800	—
Magnesium (Mg)	—	1,300	—
Cadmium (Cd)	—	15	3
Chromium (Cr)	—	0	0
Cobalt (Co)	—	0	0
Copper (Cu)	10	8	—
Lead (Pb)	0	20	—
Nickel (Ni)	0	0	0
Strontium (Sr)	—	0	—
Zinc (Zn)	10	5	4

Roaring Brook Estates' well Lk-320 was drilled along the stream, and a chemical analysis revealed 0.50 mg/l manganese, 7.9 mg/l iron, and trace amounts of other metals (see analysis, Table 20).

Atmospheric Gases and Particulate Emissions

Sulfurous gases in the valley are easily detected because of their pungent odor. Not so easily detected are emissions of more volatile metals, which sublime at temperatures of 1,000 to 1,750°F (temperatures recorded by the U. S. Bureau of Mines, M. E. Hager, personal commun., 1969), common to burning cast piles and underground mine fires. Recently (1969), in an effort to extinguish fires, tons of water have been hosed onto burning cast piles. Condensing steam, along with volatilized metal oxides, is carried away by the wind and returned to the earth by precipitation. Reservoirs and lakes downwind that do not have a large buffering capacity may increase in trace-metal concentration from this source. Trace-metal analyses of water sampled at three burning cast piles being extinguished by water are shown in Table 12.

Table 12. *Trace-Metal Analyses of Waste Water Used to Extinguish Burning Culm Banks*

(In micrograms per liter, except as indicated)

Constituent	Olyphant bank near Olyphant	Baker bank near Scranton	Huber bank,[1] Wilkes-Barre[2]
Specific conductance (micromhos)	2,050	1,100	5,000
Temperature (°C)	70	79	88
pH	3.5	6.4	5.5
Iron (Fe)	870	400	270,000
Manganese (Mn)	11,000	600	91,000
Cadmium (Cd)	8	1	0
Cobalt (Co)	290	8	1,800
Copper (Cu)	150	2	250
Lead (Pb)	20	3	0
Nickel (Ni)	960	12	3,300
Zinc (Zn)	112	6	3,800

[1] Water from deep mines is used to quench fire.
[2] Luzerne County.

CHEMICAL CHARACTER OF WATER IN THE GEOLOGIC FORMATIONS

Results of the comprehensive inorganic analyses of ground-water samples are listed in Table 20. The chemical character of ground water in Lackawanna County is shown graphically on trilinear diagrams of cations and anions shown in Figure 19. The illustration serves to compare the concentrations of three cations and anions, as expressed in percentages of reacting

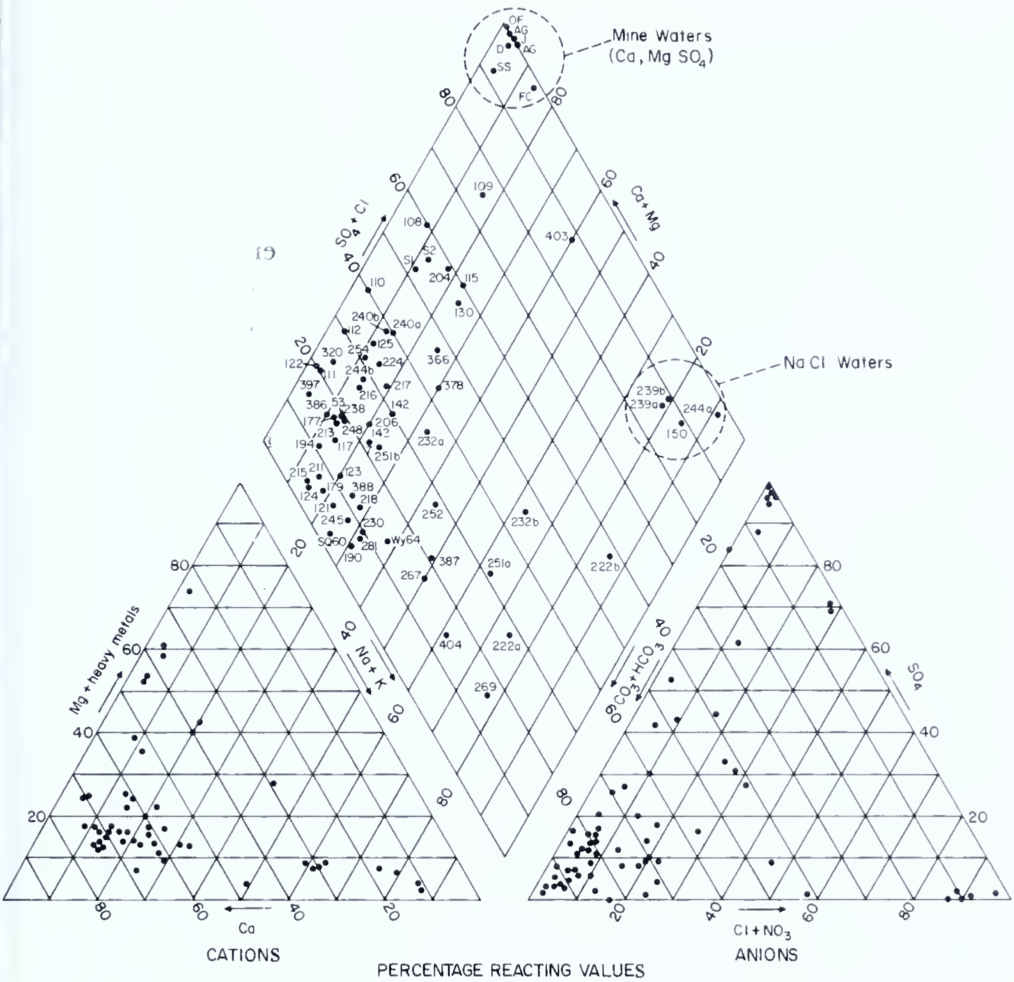


Figure 19. Trilinear diagram of chemical analyses of ground water.

values. Most wells yield water containing high percentages of calcium and even higher percentages of bicarbonate. A few wells yield water high in sodium and chloride. Mine water is extremely high in sulfate.

The diamond field diagram (Figure 19) provides a general classification of ground-water type. The areas outlined are indicative of water from different geologic units and zones. Most of the analyses plot on the left side of the diamond and are classified as a calcium magnesium bicarbonate type. This type is relatively low in dissolved solids. The analyses that plot in the top and bottom quarters are classified as calcium sulfate or sodium bicarbonate types. These types are generally higher in dissolved solids than the analyses that plot on the left, but lower in dissolved solids than the analyses that plot on the right (sodium chloride type).

The plot of the analyses of water from the Catskill Formation is generally scattered on the diamond field diagram. About 87 percent of the analyses

plot in the left quarter of the diagram and are dilute water of the calcium bicarbonate type. About 13 percent of the analyses are of the sodium bicarbonate and sodium chloride types and constitute the more highly mineralized waters.

Water from the Pocono Formation is mostly dilute and of the calcium bicarbonate and ferrous bicarbonate types. A few analyses plot on the upper quarter of the diamond field diagram and are of the calcium sulfate type.

Water from the Pottsville Formation is of the ferrous bicarbonate type, with the exception of that from one well (Lk-403), 600 feet deep, in the lower part of the Lackawanna Valley, which yields water of the ferrous sulfate type.

The ratios, by weight, of various cations and anions were compared with dissolved solids. The magnesium/calcium ratios for ground water from the plateaus generally decrease as mineralization increases, probably because the magnesium in shale is fixed in the clay minerals; however, magnesium/calcium ratios increase slightly as mineralization increases in water from the mines, probably because of decomposition of the alumino-silicate lattice in the shale. Calcium/sodium ratios for ground water from the plateaus decrease as mineralization increases and probably represent the mixture of various percentage compositions of fresh meteoric water and concentrated brines. Water-softener waste and road salt also may cause this trend. Chloride/bicarbonate ratios for all ground water increase as mineralization increases. Sulfate/bicarbonate ratios for all ground water from the plateaus increase as mineralization decreases. In the Lackawanna Valley, however, this ratio increases as mineralization increases for mine water, where pyrite oxidation contributes large amounts of sulfate.

Generally, water from wells in the high-yielding glaciofluvial deposits is moderately hard and contains less than 100 mg/l dissolved solids.

Water from till is hard and generally contains more than 100 mg/l dissolved solids. Because of their shallow depth and susceptibility to pollution, many wells tapping the unconsolidated deposits yield water that has greater concentrations of chloride, nitrate, and organic materials than water from bedrock wells.

Water-quality characteristics of the various geologic units are summarized in Table 13. The sum of dissolved constituents is compared with the percentage cation concentration. Water from the Pocono and Pottsville Formations has a greater percentage of heavy metals than water from the Catskill Formation. A low dissolved-solids content is associated with an increase in percentage of heavy metals. These metals include the total equivalents of iron, manganese, zinc, copper, and aluminum.

Table 13. *Average Percentage Cation Concentrations in Water from Wells Tapping Four Geologic Units in Lackawanna County*

Formation or deposit	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Heavy metals	Sum of dissolved constituents (mg/l)
Catskill	55	14	30	1	248
Pocono	50	25	6	19	60
Pottsville	28	25	3	44	144
Quaternary	66	20	14	0	82

Undesirable Properties

Although most of the wells in the county yield water of good to excellent quality, water from wells in some places contains minerals undesirable in drinking water. Almost 70 percent of the producing wells yield water of excellent quality, having a specific conductance of less than 300 micromhos, and less than 2 percent yield water of poor quality, having a specific conductance greater than 700 micromhos (dissolved-solids content equals approximately 65 percent of the specific conductance) (see Figure 20). The areas where ground water may be high in dissolved solids, very hard, high in iron and manganese, have an odor of hydrogen sulfide, or may lack sufficient neutralizing or buffering capacity (bicarbonate) are delineated in Figures 21 through 24 and are discussed in the succeeding paragraphs.

Hardness

Hardness is directly related to the calcium and magnesium content of the aquifer. In Lackawanna County calcium and magnesium occur principally as calcareous (limy) interstitial cement in calcareous shale units and as thin dolomitic calcarenites in the Catskill Formation. The relationship of geology to water hardness can be illustrated by analysis of water from the Lackawanna River. Carbonate hardness is relatively high in the upper reaches of the river that drain the Catskill, and noncarbonate hardness is dominant in the lower reaches, where sulfate-type water from mine discharges has been added. In the Catskill, some shale and siltstone aquifers contain calcium sulfate water in certain water-yielding zones (wells Lk-108 and 109, and spring Lk-Sp-2). In some shale areas, a natural water-softening process occurs, and sodium content is increased at the expense of calcium and magnesium (wells Lk-222, 251, 252, 269, 404, and Wy-66). This would suggest that the shale wells may tap some connate water, which becomes

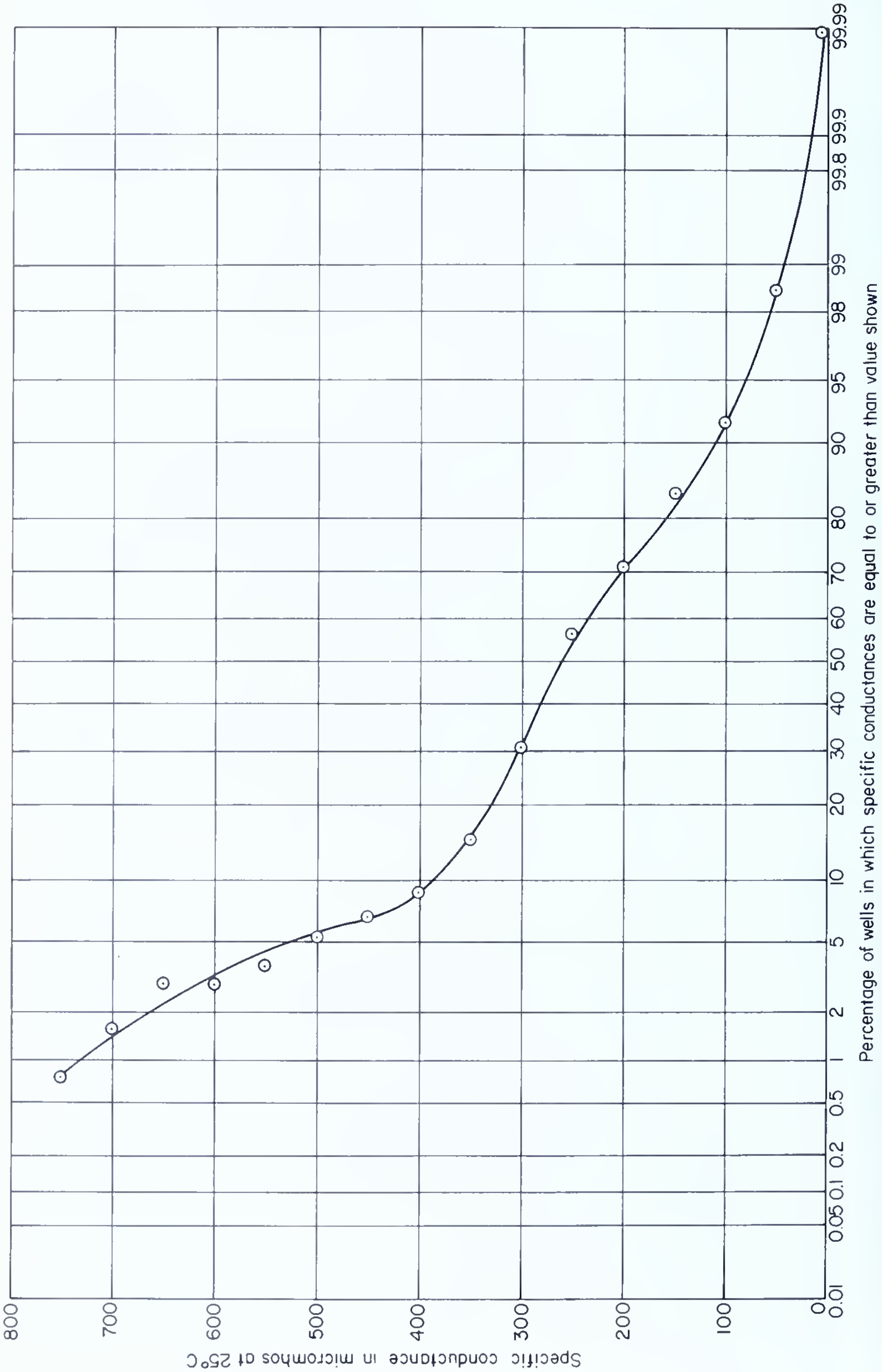


Figure 20. Cumulative-frequency distribution of specific conductances of well water.

mixed with fresh water near the surface. These wells are all in the zone shown by a cross-hatch pattern on Figure 21.

Areas of equal hardness shown on the map are not coincident with the areas of equal bicarbonate concentration (Figure 22), which indicates another source of bicarbonate besides the calcareous cement. In addition to the exchange phenomena, bicarbonate in ground water may be derived from the carbon dioxide formed by the decomposition of organic compounds in bogs and carbonaceous materials within the Catskill Formation (Hem, 1970, p. 45). Most of the water from wells in northwest Lackawanna County has high carbonate hardness; however, water from the areas to the south and east (Figure 22) has a particularly low carbonate hardness and lacks the neutralizing capacity to prevent or reduce the concentration of iron and acidity. Water in a reducing environment (low Eh) will produce a high Fe^{+2}/Fe^{+3} ratio, and includes ferrous bicarbonate in carbonate-rich areas and ferrous sulfate in carbonate-poor areas. Under reducing conditions in carbonate-poor areas, an organic complex may decompose to form methane. For example, a well in Benton Valley (Lk-150), north of Lackawanna Valley, yielded water with a high pH, a low bicarbonate content, and methane.

Iron and Manganese

Iron and manganese occur most frequently in water from the Pocono Formation, at the base of the Pottsville Formation, and in the Llewellyn Formation. These metals are also relatively common and abundant in the Catskill Formation. The red and green color of many of these rock units, especially the shale, is an indication of the presence of iron-bearing minerals. Pyrite is abundant, and manganese occurs principally as a minor association.

The U. S. Public Health Service (1962) recommends that the iron content in public water supplies not exceed 0.3 mg/l and that manganese not exceed 0.05 mg/l. Water with concentrations of iron and manganese greater than those recommended may stain fabrics, painted surfaces, and porcelain.

Little or no correlation exists between the amount of dissolved solids and the concentrations of iron and manganese in the samples. These metals generally are more concentrated in the dilute water from the Catskill Formation and from waters of the Pocono and Pottsville Formations than they are in the average fresh water of the plateau (Table 13). One-third of the wells for which determinations of iron were made (Table 20) had water with an iron content greater than 0.3 mg/l, and more than one-third of the wells yielded water with a manganese content greater than 0.05 mg/l. The areas that have an iron and manganese problem are delineated in Figure 23. Table 13 shows the average heavy metal content (mostly iron and manganese) as a percentage of the total cations in 194 water samples taken from wells tapping the geologic units in the county.

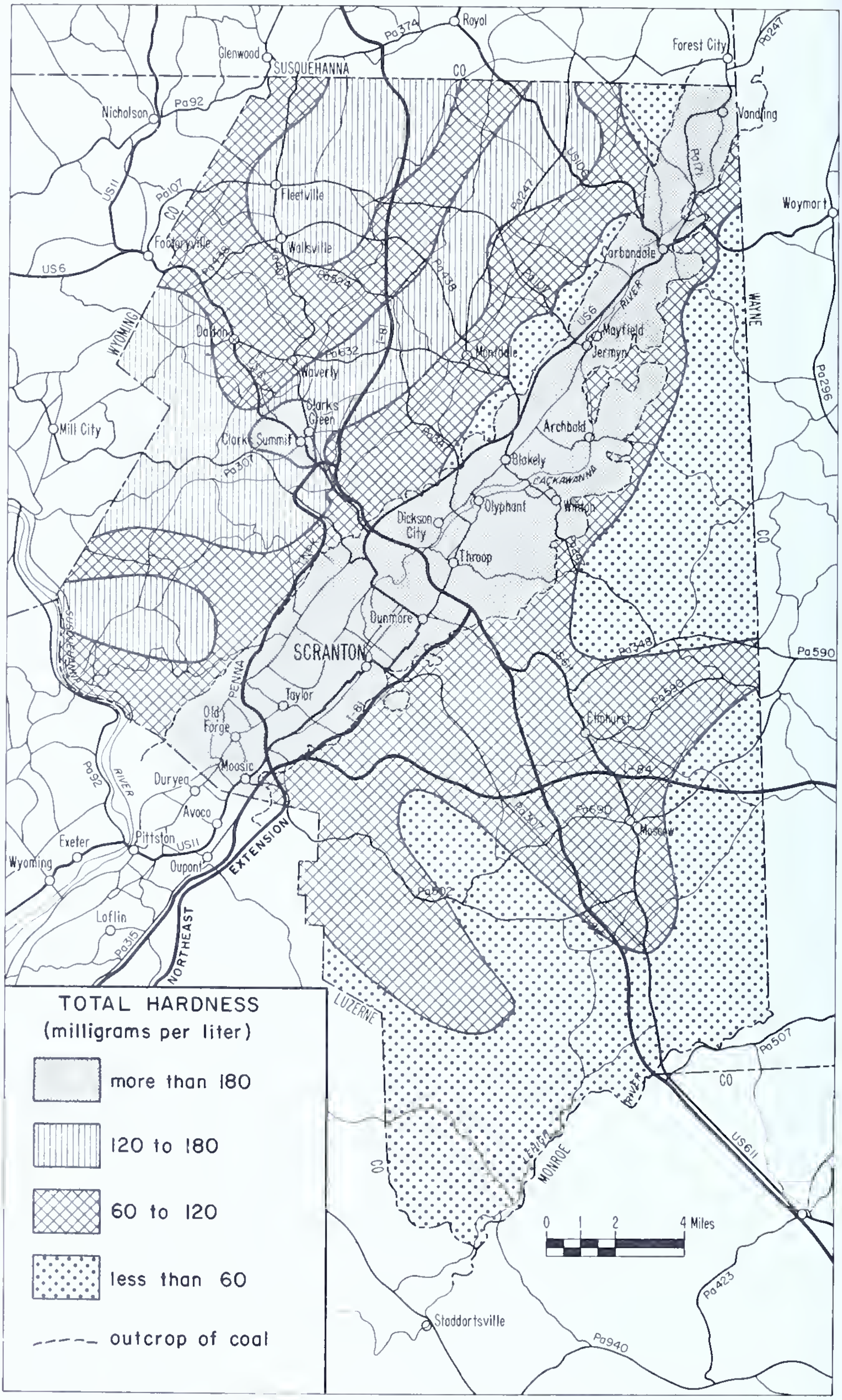


Figure 21. Hardness in ground water in Lackawanna County.

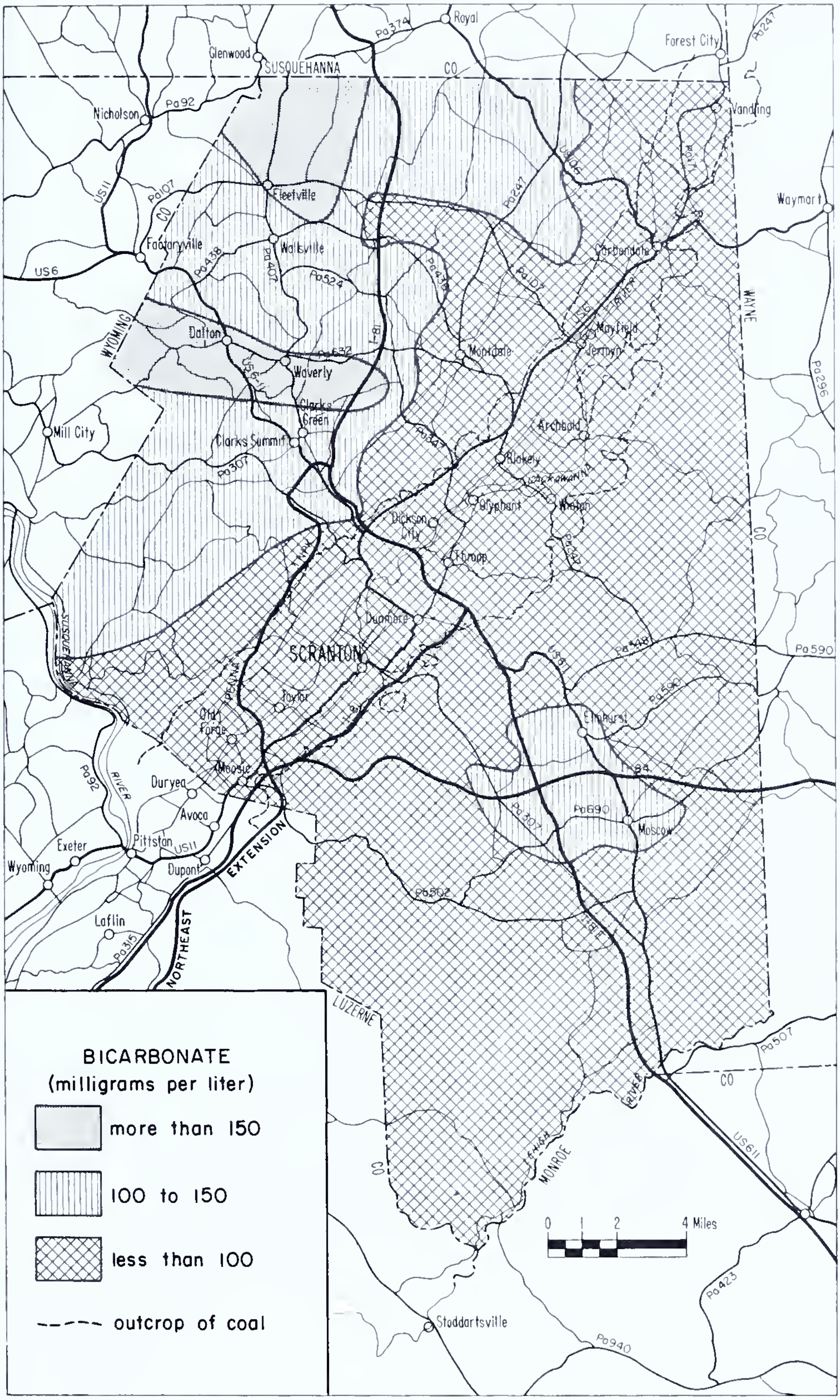


Figure 22. Bicarbonate in ground water in Lackawanna County.

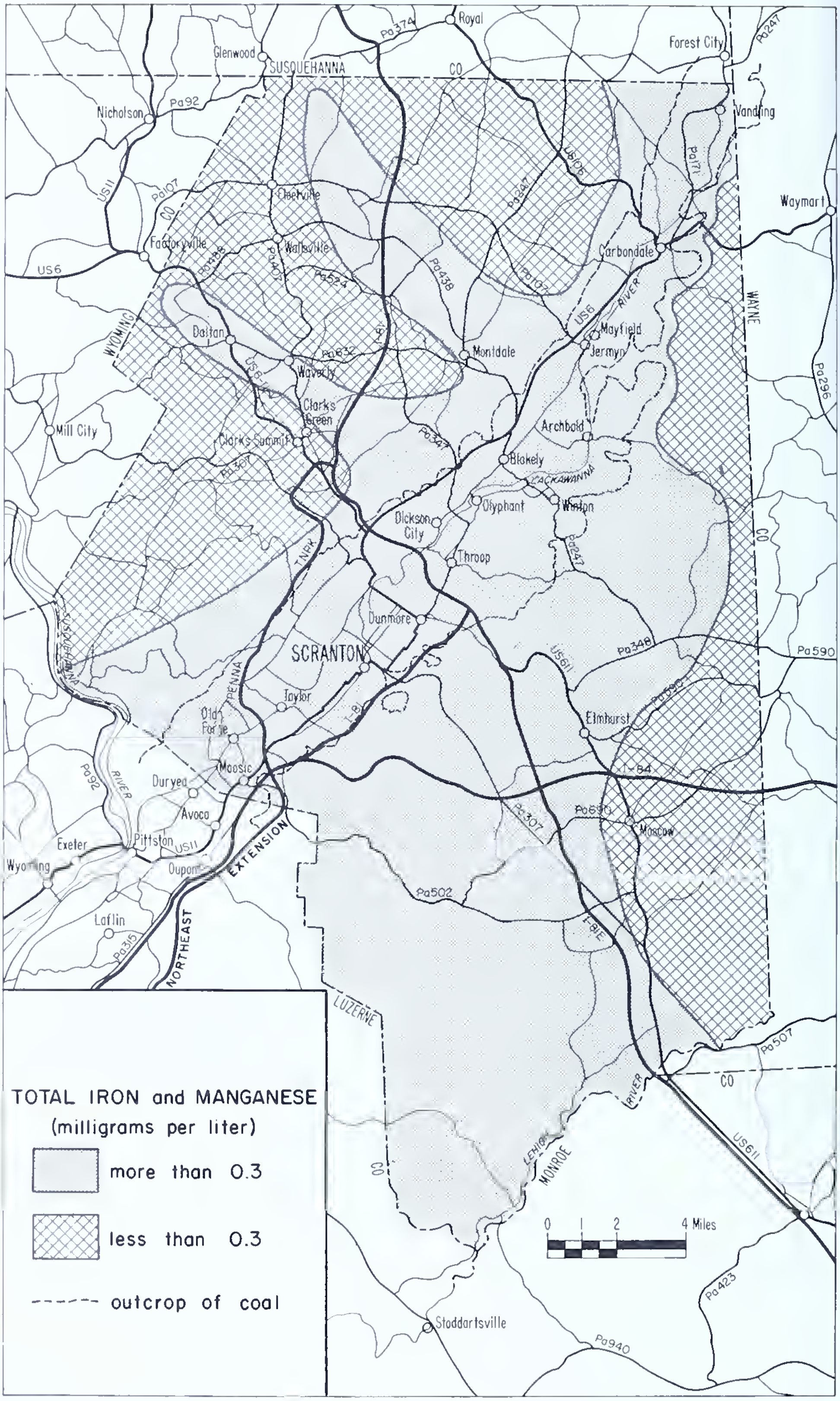


Figure 23. Iron plus manganese in ground water in Lackawanna County.

Iron can be removed by oxidation. The common methods in use are aeration and chlorination, followed by filtering or settling. Manganese, which has a much higher redox potential, resists oxidation and can be removed only by the addition of phosphate. Commercial units are available for iron and manganese removal, even for domestic supplies.

Hydrogen Sulfide

Hydrogen sulfide (H_2S) imparts sulfurous or "rotten-egg" odor to water. Many wells completed in the Catskill Formation contain hydrogen sulfide. Concentrations of hydrogen sulfide dissolved in the water range from trace amounts to 5 mg/l and are most abundant in those areas shown by a dot pattern on Figure 24. Samples were not analyzed in the laboratory for hydrogen sulfide content, but the gas was detected by odor and analyzed in the field using portable laboratory equipment.

The deeper wells most commonly produce hydrogen sulfide. The gas is harmless in the small quantities usually found, but it is toxic in large amounts. Other gases, including methane, often occur with the hydrogen sulfide and create a potential fire or explosion hazard unless wells are properly vented. Most of the hydrogen sulfide can be removed by aeration and by addition of an excess of chlorine. However, before the water can be used the excess chlorine must be removed; this can be done by adding sodium bisulfite. The complexity of the problem is such that many households and water companies have abandoned wells that yield water containing undesirable amounts of hydrogen sulfide.

Salt Water

Most chloride concentrations in ground water in Lackawanna County are well below the amount that can be tasted. However, a few deep wells were found to yield saline water. Areas where salty ground water is likely are shown by a dot pattern on Figure 24. Predicting the areas where salt water may occur requires an understanding of its origin. The possible sources for high chloride in ground water include pollution, salt enclosed in the rock units, or salt water (connate water) trapped at depth within the rock. Isolated salt springs are not rare in the history of the area (Craft, 1891). Salt springs were found before the turn of the century by early settlers along Roaring Brook, about 5 miles above its mouth.

Most of the salty ground water in the northwestern part of the county can be attributed to the flushing of salt water from deep fractures in areas of high ground-water head. The brines are being flushed out of the uppermost 600 feet of bedrock by fresh water, and the saline mixtures are slowly moving toward discharge areas. Evidence of this flushing may be seen in two analyses made 60 years apart on water from a flowing well (Wy-66) in a valley (Table 14). Water flushed from fractures has reduced the salinity

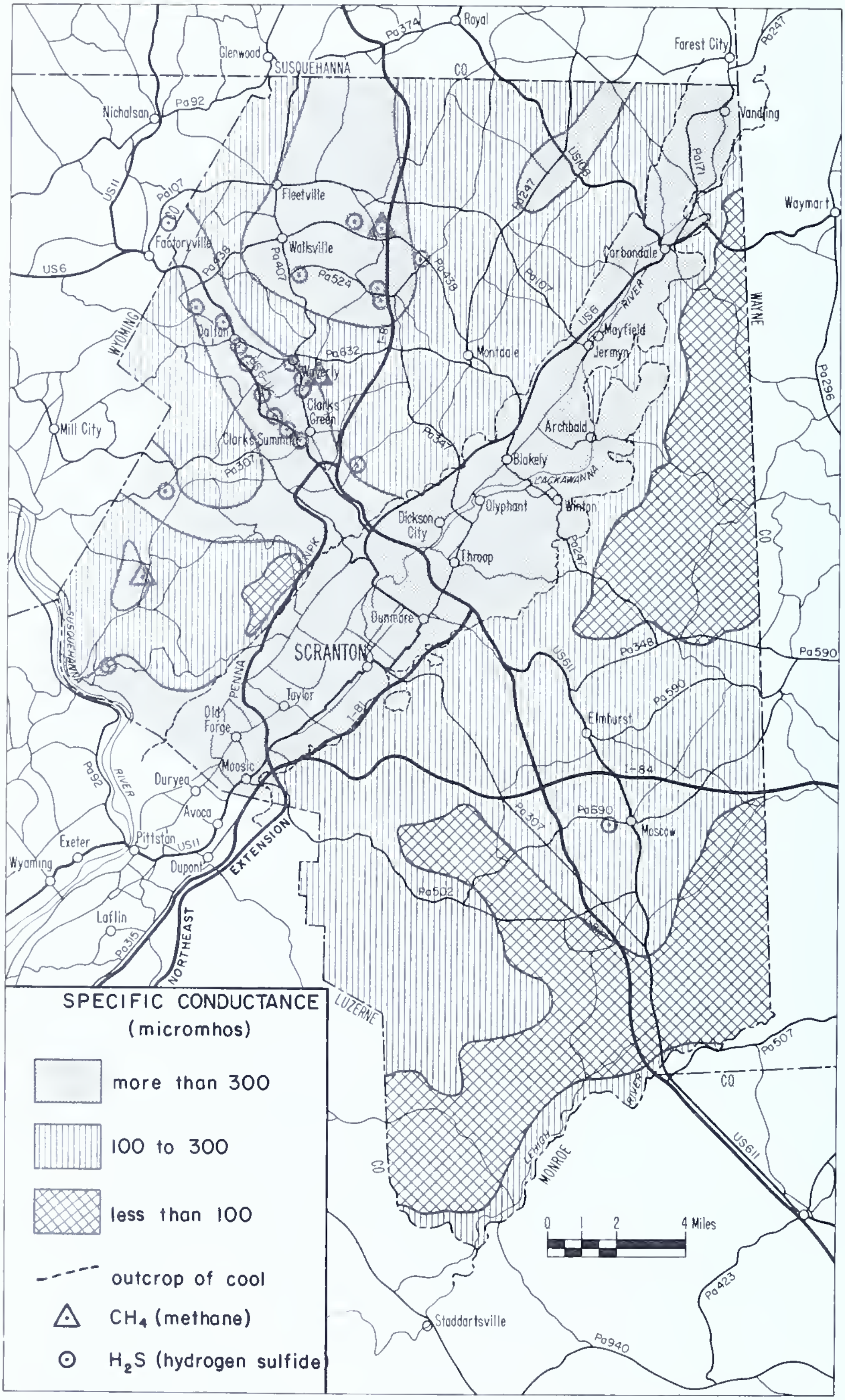


Figure 24. Specific conductances in ground water in Lackawanna County.

of water from this well over 450 percent. The depth of the well is unknown; however, it is known to be a shallow oil prospect less than 1,000 feet deep.

Table 14. ***Chemical Analyses of Water from East Mountain Lithia Well Wy-66***

(Results in milligrams per liter, except as indicated)

Constituents	Analyzed by H. T. Galpin New York City N. Y.[1]	Analyzed by U. S. Geol. Survey[2]
Discharge (flow)	—	3 gpm
Temperature	—	13.1 °C
Specific conductance (field)	—	980 micromhos
(laboratory)	—	912 micromhos
pH (field)	—	8.3 units
(laboratory)	—	8.3 units
Sum of dissolved solids	3,170	572
Hardness:		
Total	758	33
Noncarbonate	0	0
Silica (SiO_2)	4.8	8.3
Aluminum (Al)	2.1	.0
Total iron (Fe)		
Field	—	.12
Laboratory	.17	.05
Manganese (Mn)	—	.09
Copper (Cu)	—	.00
Zinc (Zn)	—	.02
Calcium (Ca)	206	10
Magnesium (Mg)	59	2.0
Barium (Ba)	2.6	—
Lithium (Li)	1.5	.68
Sodium (Na)	636	205
Potassium (K)	59	5.0
Bicarbonate (HCO_3)	1,470	222
Sulfate (SO_4)	Trace	1.2
Chloride (Cl)	728	230
Bromide (Br)	5.8	—
Fluoride (F)	Trace	.8
Nitrate (NO_3)	—	.4
	[3]	

[1] Collected approximately 1910.

[2] Collected August 19, 1970.

[3] Trace amounts of: Iodine (I)
Strontium (Sr)
Phosphate (PO_4)
Boron (B)

A gradual improvement of water quality in the lower aquifer of a deep well (Lk-244) also was recorded. Water from this well had a dissolved-solids content of 3,700 mg/l when it was first drilled in 1962. In 1969, a sample from the well had a dissolved-solids content of only 141 mg/l. This is probably the result of water from an upper aquifer, flowing down the well bore into a lower aquifer containing saline water, and flushing the more dense saline water away from the well bore. Heavy pumping of the well could reverse this flow system and cause a return of the saline water to the well.

Geophysical techniques were used for obtaining subsurfaee information on the producing saline-water zones. Gamma-ray, electric, and fluid-resistivity logs were made on the Clarks Summit Water Company well (Lk-222) in Dalton. The well was drilled in 1907, and no information is available about the formations penetrated, number of water-bearing zones, and source of water. The electric and fluid-resistivity logs (Figure 25) show a sharp departure from the base line at the bottom of the casing. The electric and gamma-ray logs show a zone below the casing at a depth of approximately 330 feet that yields most of the water to the well. This zone, having the greater head, provides most, if not all, the water when the well is flowing. The gamma-ray log shows a sharp response at a depth of 334 feet, which may represent a confining bed of shale. The fluid-resistivity log shows that the quality of water deteriorates rapidly below a depth of 332 feet, just above the confining bed.

Table 15 shows that the variable water quality obtained from well Lk-222 is related to the rate of discharge at the well head. When flowing, the well yields water having a much lower dissolved-solids content than when the well is pumped. The inerease in dissolved constituents is almost exclusively sodium chloride. Most or all of the water flowing from the well is leaking into the well at the bottom of the casing, 284 feet below land surface. This water is low in dissolved solids. When the well is pumped, water is also drawn from the deeper (saline) zone, about 334 feet below land surface. Thus, the pumping well yields a mixed water of poor quality.

Gamma-ray, electric, and fluid-resistivity logs were made for well Lk-232, near Waverly. Electric and gamma-ray logs showed almost identical down-hole information on the geologic units. Fluid-resistivity logs showed that the water quality deteriorated rapidly below a depth of 300 feet. Analyses of water sampled September 10, 1970, at depths of 80, 360, and 440 feet, showed an increase in sodium chloride concentration and an increase in hydrogen sulfide dissolved in the water as depth increased (Table 16).

Examples of wells yielding water of the sodium chloride type, all located in the northwestern part of the county, include Lk-150, 222, 235, 241, 244, and Wy-66. These probably represent a very small percentage of all the saline water wells drilled, because many wells were reported drilled

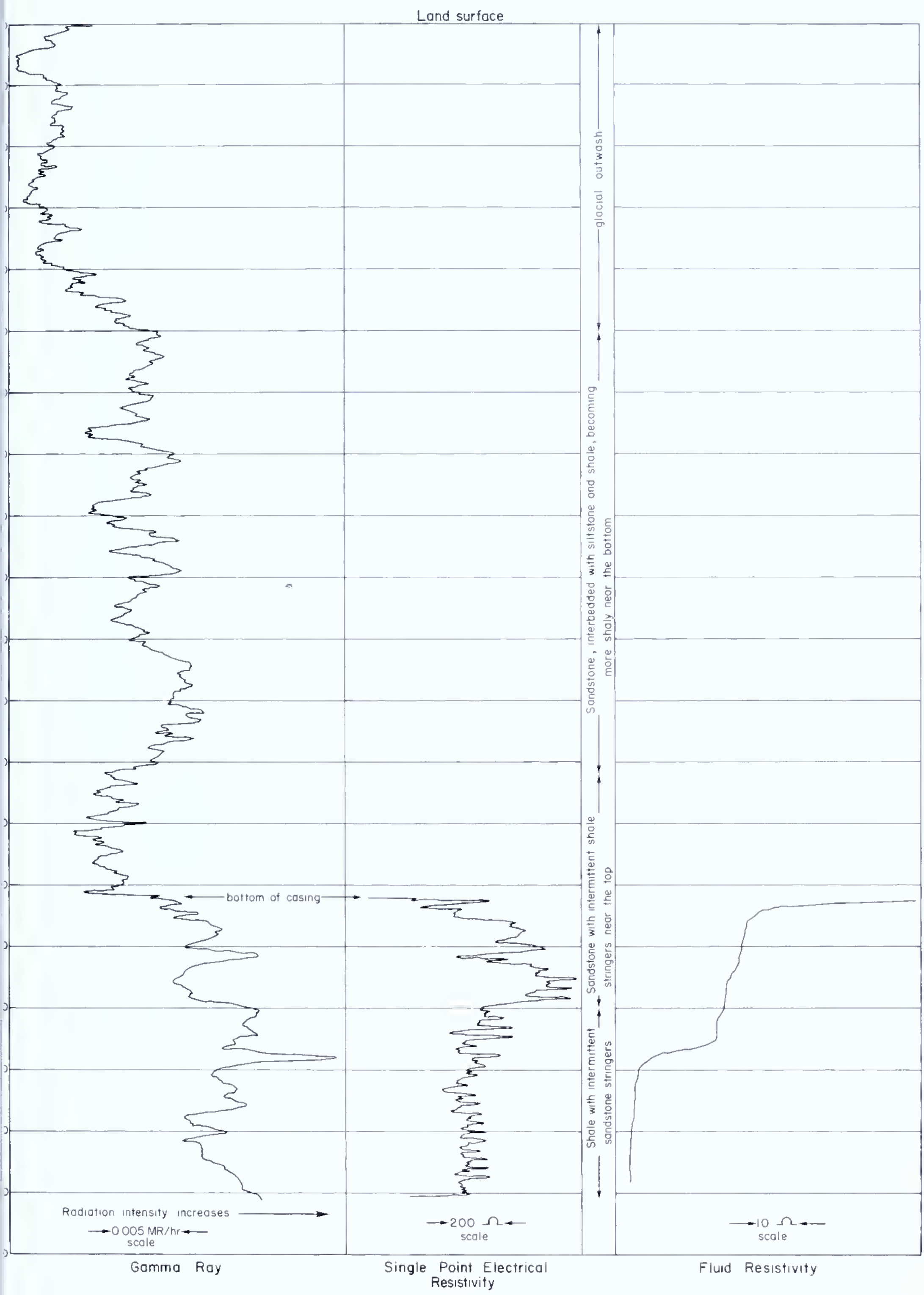


Figure 25. Geophysical logs in Dalton supply well Lk-222, logged February 1969.

Table 15. *Chemical Analyses of Water from Dalton Well Lk-222*

(Results in milligrams per liter, except as indicated)

Time since pumping began (hours)	0	2	10
Pumping level (feet below top of casing)	0	120	182
Yield (gpm)	Flowing	100	125
Field conductance ($K \times 10^{-6}$)	355	645	670
pH (field)	7.4	7.8	7.9
(laboratory)	8.1	8.2	8.2
Temperature (°C)	8.7	10.2	10.4
Total hardness (as $CaCO_3$)	42	32	44
Hydrogen sulfide (H_2S) (field)	3.5	2.0	1.5
Silica (SiO_2)	9.2	—	8.9
Calcium (Ca)	12	10	15
Magnesium (Mg)	3.0	1.6	1.5
Sodium (Na)	57	—	130
Potassium (K)	6.0	—	6.7
Bicarbonate (HCO_3)	161	168	168
Sulfate (SO_4)	6.9	—	3.2
Chloride (Cl)	32	126	132
Fluoride (F)	—	—	.2
Nitrate (NO_3)	.2	—	.4
Aluminum (Al)	.0	—	.0
Iron (Fe)	.80	1.1	.70
Manganese (Mn)	.04	.05	.04
Copper (Cu)	.00	—	.01
Zinc (Zn)	.05	—	.02
Sum of dissolved solids	206	—	382

into saline-water zones and were subsequently plugged off or abandoned.

Other sources of salt pollution are home and industrial water softeners that are discharged into drain fields, sewage discharged through septic tanks and drain fields, and salt spread on roads and highways. About one-fourth of the homes visited during well inventory had water softeners. Per-capita daily water use of softened water is about 50 gallons. Assuming half a pound of salt is needed for each 1,000 grains of hardness, a community of 10,000, having only septic-tank sewage disposal, adds anywhere from 80 to 114 tons of salt to aquifers each year.

Nitrate and Phosphate

The nitrate content of ground water in the county averages 2.85 mg/l and ranges from 0.0 to 12 mg/l, which is well below the 45 mg/l limit for drinking water recommended by the U. S. Public Health Service (1962). Phosphate was not determined routinely, but where determined, concentrations ranged from 0.01 to 0.85 mg/l. Nitrate and phosphate are end products of oxidation of organic nitrogen and phosphorus in plant debris,

Table 16. *Chemical Analyses of Water from Well Lk-232*
(Results in milligrams per liter, except as indicated)

Constituent	Depth sampled (in feet)		
	80[a]	360	440
Specific conductance (micromhos)	398	448	535
pH (laboratory)	7.8	7.8	7.6
Temperature (°C)	9.7	10.2	10.7
Hardness (as $CaCO_3$)			
Total	127	127	111
Noncarbonate	3	1	0
Silica (SiO_2)	9.5	—	9.2
Aluminum (Al)	.0	—	.0
Total iron (Fe)	.09	.50	.60
Manganese (Mn)	.06	.28	.26
Copper (Cu)	.00	—	.00
Zinc (Zn)	.02	—	.04
Calcium (Ca)	41	41	36
Magnesium (Mg)	6.0	6.0	5.0
Sodium plus potassium (as Na)	29	36	83
Bicarbonate (HCO_3)	152	154	160
Sulfate (SO_4)	32	25	26
Chloride (Cl)	21	31	89
Fluoride (F)	.1	—	.2
Nitrate (NO_3)	8.0	11	9.8
Hydrogen sulfide (H_2S)	Odor	.5	1.8
Sum of dissolved constituents	222	237	340

[a] Pump intake.

animal excreta, organic and inorganic fertilizers, and detergents. High nitrate and phosphate concentrations generally indicate the addition of these constituents to ground water from waste lagoons, septic tanks, barnyards, and fertilized fields, which are found in the area. Unpolluted water seldom contains more than 10 mg/l of nitrate as an upper limit (George and Hastings, 1951). Low concentrations of nitrate (less than 5 mg/l) may result from natural decomposition of plants and bacterial metabolism or nitrogen fixation. Thus, the numerous swamps and bogs on the plateau may also be a source of nitrate.

Ideally, water wells are drilled as far as possible from known sources of pollution. In deep wells tapping multiple aquifers, pollution from sources near the surface would be minimized if shallow-yielding zones were cased off. Wells cased to shallow depths below land surface generally yield water having the greatest concentrations of nitrate. This relationship is shown in Figure 26.

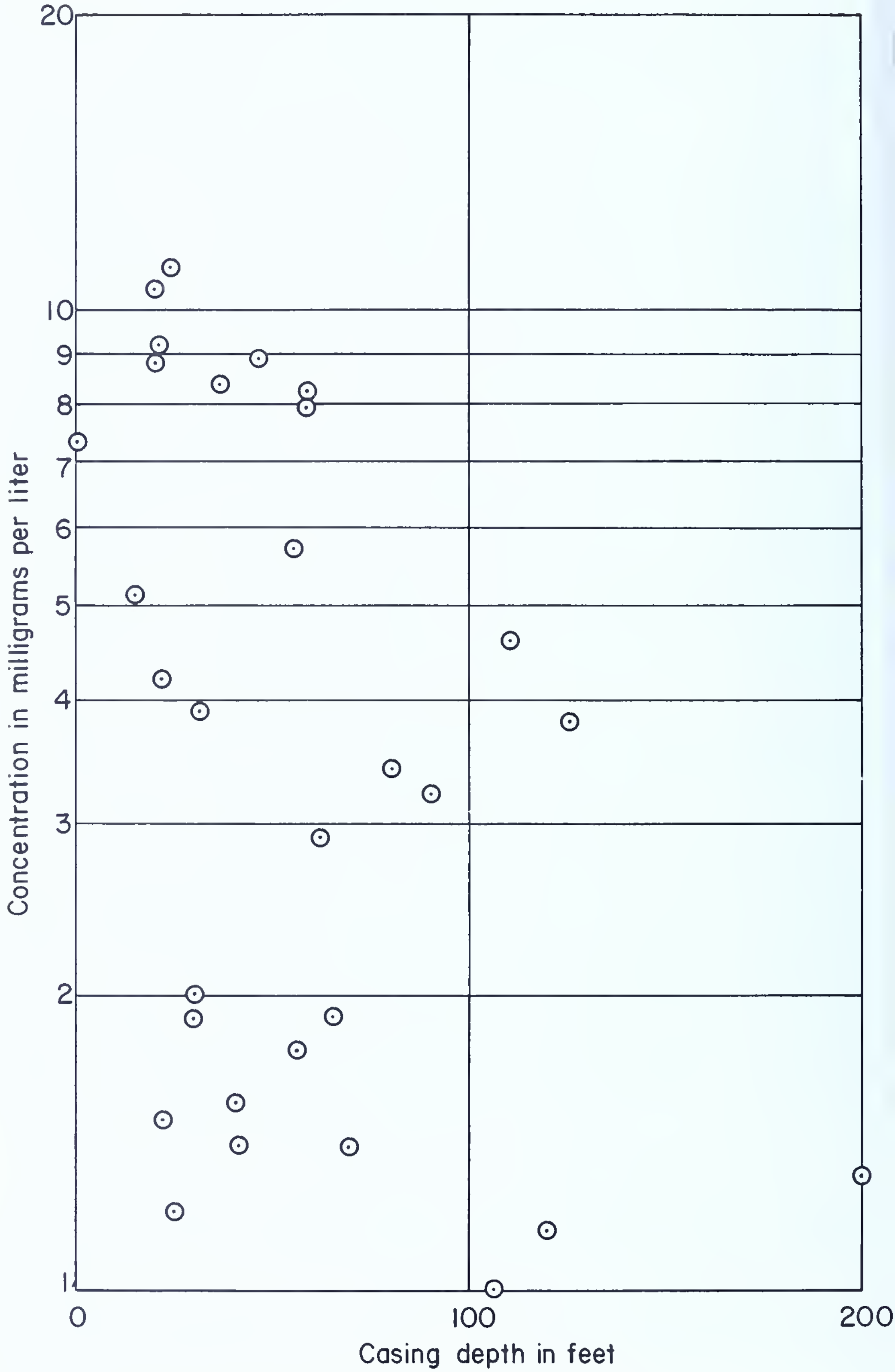


Figure 26. Relation of nitrate concentration and casing depth.

No differentiation was made between compounds of nitrogen and phosphorus that originated from chemical fertilizers and those that originated from barnyard runoff, raw or treated sewage, or nitrates formed naturally in the soil. However, high nitrate with a corresponding increase in chloride may indicate sewage pollution, and bacterial pollution should be suspected in wells Lk-89, 108, 232, and 252. Unless a well is grossly polluted, chlorination of drinking water can prevent severe health problems due to bacteria.

CONCLUSIONS

Lackawanna County has one of the largest urban populations in northeastern Pennsylvania. This population is concentrated within the Lackawanna Valley (the Northern Anthracite field). Since 1960, suburban development away from the valley onto the adjacent plateaus has created a demand, locally, for high-yielding water-supply wells. Because of the nature of the bedrock aquifer underlying the plateaus, high-yielding wells are difficult to obtain.

Most ground water from the plateaus is of the calcium magnesium bicarbonate type (Table 20). However, some water of poorer quality occurs in deep valleys common to major fractured zones. This water is of the sodium bicarbonate type, generally having an odor of hydrogen sulfide, or of the sodium chloride type.

Large supplies of water of good quality may be obtained throughout most of the plateaus along linear zones of highly fractured rock. These zones, field tested at several locations, yielded 100 to 300 gpm to wells, 10 times the yield of the average well drilled for domestic needs. Numerous high-yielding wells may be located along these linear fracture zones; however, wells spaced too closely will have mutual interference. The amount of interference depends upon their proximity. For example, the water level in an observation well declined approximately 2 inches in response to pumping of a well at 140 gpm, 3,000 feet away, for 18 hours. Another observation well declined 11 feet in response to pumping of a well 100 gpm, 1,200 feet away, for 24 hours. Production wells tapping a common or intersecting fracture system would probably not interfere with each other appreciably if they were spaced 2,000 to 3,000 feet apart. Wells could be spaced 1,000 to 2,000 feet apart provided they do not tap the same fracture zone.

Public water supplies in the Lackawanna Valley (Table 19) are obtained from reservoirs in the mountains surrounding the valley. This source of supply is adequate for present and near-future needs, but projected needs for the year 1990 will probably exceed the supply available from the surface sources. Ground-water supplies could be used to augment the surface supplies.

Isolated deposits of coarse sand and gravel may also yield large quantities of water of good quality; however, most of these deposits are small and few are ideally located for exploitation. Wells yielding 50 to 300 gpm have been drilled and tested in such deposits.

The Lackawanna Valley has been intensely deep mined and strip mined throughout the area underlain by anthracite. This mining has opened vast underground waterways that allow water to move from the surface to points of discharge. Because of local geologic structure and barrier pillar conditions, numerous underground pools and individual overflows have formed since underground mining ceased. The discharge from the largest pool ranges from 50 to 180 cfs (cubic feet per second) and averages 107 cfs.

The average dissolved-solids content of Lackawanna River water ranges from 44 mg/l near Forest City to 566 mg/l at Old Forge. With adequate treatment, mine water and river water in the upper one-third of the basin may be considered potential water supplies for some future industrial and domestic needs. The chemical quality of surface water outside the Lackawanna Valley is better than the treated water for most large cities in the United States, and surface water south of the valley is of excellent quality and has a dissolved-solids content ranging from 24 mg/l to 55 mg/l.

The hydrochemical maps (Figures 21-24) show areas of hard water, bicarbonate water, saline water, and water high in metals. Water having high concentrations of ferrous iron indicates areas of low oxygen and a low redox potential. Water having a high concentration of bicarbonate may have a high pH and low Eh and a high Fe^{+2}/Fe^{+3} ratio. Methane is present in some water and may be derived from the decomposition of organic constituents under strong reducing conditions, particularly in carbonate-poor areas. The organic constituents on the plateau may enter the ground-water system from peat bogs.

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Table 17. *Record of Wells and Springs i*

Vell number: The number that is assigned to identify the well.
It is prefixed by a two-letter abbreviation of the county.
Location number: The number is the latitude and longitude coordinates, in degrees and minute of the southeast corner of a one-minute quadrangle within which the well is located. We locations are shown on Plate 2.
Jse: C, commercial; F, fire; H, domestic; I, irrigation; N, industrial; P, public supply; R, recrea tion; S, stock; T, institutional; U, unused; Z, sewage disposal plant.

Well no.	Location no.	Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographi setting
						LACKAWANN	
Lk- 1	4125-7547	Klipple, J. W.	—	1926	H	1095	S
2	4133-7529	Ransom, O. J., Nursery	—	—	I	1615	S
3	4123-7549	Hughes, W.	Sprague & Henwood, Inc.	1929	H	600	T
4	4113-7537	Pine, J. A., M.D.	—	—	P	1910	S
5	4123-7539	Zymkoski, Richard	—	—	H	770	S
6	4129-7546	Stanton, E. H.	—	—	H	1190	H
7	4134-7528	Reynshanhurst 3	—	1890	P	1400	W
9	4123-7548	Ransom-Newton State Hosp.	Sprague & Henwood, Inc.	—	T	620	T
10	4110-7535	Methodist Ch.	—	1910	P	1580	V
11	4110-7535	Heller, Clinton	—	—	H	1530	C
12	4110-7534	Jones, T. E.	—	—	H	1580	V
13	4112-7536	Stegmaier, C. F.	—	—	H	1800	W
14	4112-7537	Wolf	—	—	H	1900	W
15	4134-7528	Reynshanhurst 1	—	1920	U	1360	W
16	4128-7539	Bell Mt. Com. Water Assoc.	—	1953	P	1420	S
18	4125-7543	Howells, Mose or Mrs. Eliz.	—	—	H	1410	S
19	4113-7537	Pine, J. A., M.D.	—	—	P	1910	S
28	4127-7546	Stempkoski, John	Cresswell Drilling Co.	1966	H	1160	W
29	4125-7545	Rosenkrans, Morvison	do.	1966	H	1230	S
30	4125-7547	Kresge Construction Agcy.	do.	1969	H	1145	H
31	4123-7549	Sutter, Glenn	do.	1964	H	600	T
32	4123-7549	LaRue, Duane	do.	1962	H	610	T
33	4124-7549	Macheska, Thomas	do.	1961	H	965	S
34	4124-7549	Lacoe, Ellsworth	do.	1964	H	970	S
35	4123-7549	Huggler, Albert	do.	1963	H	670	S
36	4124-7546	Coolbaugh, William	do.	—	H	1290	S
37	4125-7548	Suprich, George	do.	1963	H	1060	S
38	4125-7547	Petty, George	do.	1958	H	1150	H
39	4126-7546	Miller, Loren	do.	1966	S	1066	S
40	4123-7549	Swanee Paper Co.	—	1962	U	580	T
41	4123-7549	Degilio, Nicholas, Jr.	Cresswell Drilling Co.	1965	H	650	T
42	4127-7547	Newton Ransom High Sch.	do.	1962	T	1166	S
43	4126-7547	Herron, Richard	do.	1964	H	1140	H
44	4127-7545	Sakevicus, Stephen	do.	1954	H	1145	S
45	4127-7546	Koerner, Ines	do.	1964	H	1110	W
46	4127-7546	Carr, Edmund	do.	1963	H	1190	S
47	4128-7546	Lytle, Ralph, Sr.	do.	1967	H	1070	V
48	4128-7547	Kelley, Hubert	do.	1967	H	1070	V
49	4128-7547	Grover, Keith	do.	1964	H	1023	W
50	4127-7547	Barrett, J. B.	do.	1967	H	1260	H
51	4129-7545	Shafer, Frank	do.	1957	H	1120	S
52	4127-7546	Lozinger, John	do.	1966	H	1190	S
53	4125-7547	Thompson Dairy Bar	Stanley Thomas	1967	P	1140	H
54	4127-7546	Romanowski, Charles	Cresswell Drilling Co.	1963	H	1040	S

ackawanna and Adjoining Counties

opographic setting: C, stream channel; H, hilltop; L, lake or swamp; S, hillside; T, alluvial terrace; V, valley flat; W, hillside drainageway.

quifer: Qal, alluvium; Qgo, glacial outwash; Pp, Pottsville Formation; MDp, Pocono Formation; Dck, Catskill Formation.

ithology: cgl, conglomerate; fr, fractured rock; sd, sand; sdgv, sand and gravel.

tatic water level: F, flowing; +, above land surface.

umping data: gpm, gallons per minute; DD, drawdown.

Iardness: gpg, grains per gallon.

	Total depth below land surface	Casing		Depth(s) to water-bearing zone(s)	Static water level		Pumping data				Specific conductance	
ıquifer/ thology	(feet)	Depth (feet)	Diameter (inches)	(feet)	Depth below land surface (feet)	Date measured	Yield (gpm)	DD (ft)	Time (hr)	Hardness (gpg)	(micromhos at 25°C)	pH
OUNTY												
)ck/fr	143	100	6	—	40	—	24	—	—	—	—	—
ʅgo/sdgv	20	20	24	—	10	11/31	—	—	—	—	—	—
)ck/fr	130	18	8	—	50	—	75	25	1	—	—	—
)ck/fr	10	—	36	—	4	6/53	—	—	—	—	—	—
ʅgo/sdgv	16	—	—	—	8	9/54	—	—	—	—	—	—
ʅgo/sdgv	31	—	—	—	27	7/69	—	—	—	—	—	—
)ck/fr	—	—	10	—	F	—	70	—	—	2	72	6.8
)ck/fr	227	70	8	—	14	—	90	25	96	—	—	—
)ck/fr	101	12	6	—	35	—	—	—	—	—	—	—
)ck/fr	50	10	6	—	25	—	—	—	—	—	—	—
)ck/fr	77	20	6	—	20	—	6	—	—	—	—	—
)ck/fr	200	60	6	—	50	—	25	25	—	—	—	—
)ck/fr	209	36	6	—	19	—	—	—	—	—	—	—
)ck/fr	—	—	6	—	F	—	4	—	—	3	130	7.1
ʾp/cgl	300	—	—	—	F	—	—	—	—	—	—	—
ʾp/cgl	25	—	24	—	—	—	—	—	—	—	—	—
)ck/fr	82	—	6	—	—	6/48	—	—	—	—	—	—
)ck/fr	195	20	6	160	100	8/66	8	55	2	—	—	—
)ck/fr	320	40	6	200, 270, 305	180	10/66	5	120	2	—	—	—
)ck/fr	305	91	6	—	180	10/69	30	100	2	—	—	—
)ck/fr	160	65	6	—	80	5/64	8	40	—	8	380	6.8
Dck/fr	129	44	6	—	65	1/62	25	25	—	8	480	6.72
Dck/fr	245	62	6	—	175	10/61	4	55	—	4	200	6.74
Dck/fr	465	43	6	300, 375, 450	—	—	55	—	—	4	—	7.3
Dck/fr	173	33	6	—	125	10/63	12	35	—	4	225	—
Dck/fr	195	96	6	—	70	—	—	50	—	6	270	—
Dck/fr	198	36	6	—	50	10/63	20	100	—	6	290	7.6
Dck/fr	269	133	6	—	220	6/58	15	20	—	8	410	7.19
Dck/fr	260	52	6	230	75	6/68	10	80	—	5	260	7.00
Dck/fr	124	43	6	—	30	8/62	20	35	—	—	—	—
Dck/fr	172	55	6	—	95	9/65	20	55	—	—	—	—
Dck/fr	208	65	6	—	100	8/62	35	75	—	5	270	7.40
Dck/fr	320	21	6	—	275	5/64	4	25	—	6	280	7.60
Dck/fr	208	131	6	—	90	4/54	—	30	—	—	295	7.78
Dck/fr	223	175	6	—	85	6/64	70	65	—	5	280	7.75
Dck/fr	273	43	6	—	100	10/63	6	100	—	6	310	—
Dck/fr	146	73	6	—	10	4/67	30	10	—	6	295	7.80
Dck/fr	183	133	6	175	30	8/67	20	30	—	6	370	—
Dck/fr	143	65	6	—	20	6/68	25	35	—	6	295	7.49
Dck/fr	436	41	6	—	248	6/68	15	152	—	6	250	7.85
Dck/fr	163	123	6	—	—	7/57	20	—	—	6	270	7.42
Dck/fr	175	41	6	—	120	11/66	7	40	—	—	—	—
Dck/fr	325	55	6	—	200	11/68	12	34	—	7	277	7.4
Dck/fr	194	69	6	—	100	11/63	20	40	—	—	—	—

Table 17

Well no.	Location no.	Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographi settin
Lk- 55	4128-7547	Warburton, Jerome	Cresswell Drilling Co.	1963	H	1100	S
56	4127-7546	Spencer, Kenneth	do.	—	H	1170	S
57	4128-7547	Rusinko, Mike	do.	1967	H	1130	W
58	4127-7547	Lacoe, Archie	—	1963	H	1190	S
59	4126-7543	Jaditz, Walter	—	1964	H	1610	S
60	4127-7543	Borowsky, Anthony	Cresswell Drilling Co.	1963	H	1490	S
61	4127-7543	Cosner, Charles	do.	1953	H	1480	S
62	4127-7543	Zeigler, John	do.	1962	H	1510	S
63	4127-7543	Horstman, Robert	do.	1964	H	1610	H
64	4127-7544	Miller, A. B.	do.	1963	H	1410	S
65	4127-7544	Racavitch, Karl	do.	1966	H	1320	S
66	4128-7540	Vail, Richard	do.	1963	H	1110	S
67	4128-7540	Oakes, John, R.	do.	1961	H	1100	S
68	4128-7540	Keller, Walter	—	1961	H	1130	S
69	4128-7540	Samuels, Hayden	Cresswell Drilling Co.	1962	H	1265	S
70	4128-7540	Aikman, Crawford	do.	1963	H	1250	V
71	4128-7541	Bailey, Herbert	do.	1961	H	1190	W
72	4128-7541	Mt. Terrace Assoc.	—	—	H	1150	W
73	4128-7542	Zimmerman, Harold	—	—	H	1360	S
74	4128-7542	Acker Drill Co.	Cresswell Drilling Co.	1968	F	1365	S
75	4128-7542	Internat. Salt Co.	do.	1962	P	1470	H
76	4128-7542	Scranton Tennis Club	—	1959	P	1480	H
77	4128-7543	Ryon, J. L.	Cresswell Drilling Co.	1960	H	1450	S
78	4128-7544	Dunlap, Robert	do.	1968	H	1440	S
79	4129-7538	Hunter, John	—	1950	H	1460	S
80	4129-7538	Stoeckel, Gene D.	Cresswell Drilling Co.	1967	H	1530	S
81	4129-7539	Evans, John B.	do.	1964	H	1430	S
82	4129-7539	Mt. Bethel Ch.	do.	1967	H	1520	S
83	4129-7539	Brown, Keith	do.	1960	H	1370	W
84	4129-7539	Love, Paul	do.	1965	H	1540	H
85	4129-7539	Cherkoski, Edward	do.	1967	H	1560	H
86	4129-7540	Reese, Carlyle	do.	1967	H	1380	S
87	4129-7540	Lisk, Harold, Jr.	do.	1960	H	1390	T
88	4129-7540	Hillcrest Motel	—	1953	P	1380	W
89	4130-7542	Hilwig, Fred, Mrs. (USGS Obs. well)	Cresswell Drilling Co.	1970	U	1130	W
90	4129-7541	Noto, Nat	do.	1958	H	1200	W
91	4129-7541	Jenkins, Grace	—	1950	H	1220	W
92	4129-7541	Clarks Summit Water Co. 4	—	—	P	1290	W
93	4129-7541	Marsh, Tom	Cresswell Drilling Co.	1963	H	1320	S
94	4129-7541	Cronin, Thomas P.	do.	1967	H	1320	S
95	4129-7541	Green, Ellis	do.	1964	H	1340	W
96	4129-7542	Krenitsky, John	—	—	H	1260	S
97	4129-7542	Shreiner, Joseph	—	1967	H	1300	S
98	4129-7542	Coffin, Gay	—	1967	H	1400	S
99	4120-7534	Roaring Brook Estates Well 3	Cresswell Drilling Co.	1970	C	1670	S
100	4129-7543	Snyder, Ben	do.	1967	H	1490	H
101	4124-7544	St. Georges Cemetry	—	1963	I	1430	W
102	4129-7543	Richards, Donald	—	1964	H	1500	H
103	4129-7544	Familetti, Joseph	Cresswell Drilling Co.	1961	H	1230	W
104	4129-7544	Dorsheimer, Mae	do.	1964	H	1190	W
105	4129-7544	Dell, John	do.	1963	H	1280	W
106	4129-7544	Surorvic, Joseph	—	1959	H	1260	W
107	4127-7543	Mazzarella, Joseph	Cresswell Drilling Co.	1967	H	1490	S
108	4126-7543	Ceresi, John	George J. Reed & Son	1960	H	1720	S
109	4126-7542	Blasi, Joseph	—	1952	H	1440	S
110	4126-7542	Phillips, Frank	—	1951	H	1540	S

Continued)

quifer/ hology	Total depth below land surface (feet)	Casing Depth (feet)	Casing Diameter (inches)	Depth(s) to water-bearing zone(s) (feet)	Static water level Depth below land surface (feet)	Static water level Date measured	Pumping data Yield (gpm)	Pumping data DD (ft)	Pumping data Time (hr)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH
ck/fr	163	51	6	—	80	11/63	20	40	—	—	—	—
ck/fr	248	103	6	—	100	—	15	100	—	—	—	—
ck/fr	312	40	6	—	105	6/67	70	45	—	—	—	—
ck/fr	291	53	6	—	—	—	—	—	—	—	—	—
ck/fr	223	23	6	—	—	—	10	—	—	—	—	—
ck/fr	260	225	6	—	150	10/63	40	50	—	—	—	—
ck/fr	260	130	6	—	150	12/53	20	100	—	—	—	—
ck/fr	242	189	4	—	180	9/62	20	40	—	—	—	—
ck/fr	315	44	6	—	225	5/64	15	50	—	—	—	—
ck/fr	199	35	6	—	150	—	15	25	—	—	—	—
ck/fr	185	103	6	—	40	10/66	20	90	—	—	—	—
ck/fr	123	22	6	—	30	10/63	8	60	—	—	—	—
ck/fr	110	21	6	—	60	3/61	30	50	—	—	—	—
ck/fr	130	105	6	—	80	2/61	—	20	—	—	—	—
ck/fr	203	22	6	—	20	8/62	7	160	—	—	—	—
ck/fr	223	54	6	—	75	10/63	25	75	—	—	—	—
Dck/fr	172	60	6	—	130	9/61	20	13	—	—	—	—
Dck/fr	325	—	—	—	90	—	—	—	—	—	—	—
Dck/fr	264	136	6	—	—	—	—	—	—	—	—	—
Dck/fr	361	112	6	213, 220, 225	80	3/68	115	260	—	—	—	—
Dck/fr	379	143	6	—	170	7/62	50	130	—	—	—	—
Dck/fr	327	64	6	—	150	5/59	—	10	—	—	—	—
Dck/fr	230	18	6	—	125	12/60	20	25	—	—	—	—
Dck/fr	441	190	6	—	190	1/68	4	210	—	—	—	—
Dck/fr	148	—	6	—	80	1950	—	40	—	—	—	—
Dck/fr	225	61	6	—	130	7/67	30	45	—	—	—	—
Dck/fr	248	147	6	—	150	8/64	15	50	—	—	—	—
Dck/fr	320	—	6	—	180	12/67	10	70	—	—	—	—
Dck/fr	154	103	6	—	80	4/60	20	40	—	—	—	—
Dck/fr	368	30	6	—	220	7/65	30	55	—	—	—	—
Dck/fr	350	31	6	250, 300	200	4/67	12	80	—	—	—	—
Dck/fr	340	143	6	—	160	8/67	30	90	—	—	—	—
Dck/fr	220	68	6	—	100	9/60	15	60	—	—	—	—
Dck/fr	145	15	6	—	—	—	40	—	—	—	—	—
Dck/fr	300	21	6	32, 57, 77	43	6/70	25	1	1	9	550	7.6
Dck/fr	150	47	6	—	17	4/58	30	19	—	—	—	—
Dck/fr	205	92	6	—	—	—	—	—	—	—	—	—
Dck/fr	509	—	—	—	177	—	150	123	—	—	—	—
Dck/fr	335	17	6	—	70	8/63	130	80	—	—	—	—
Dck/fr	200	113	6	—	60	9/67	8	115	—	—	—	—
Dck/fr	220	122	6	—	135	5/64	25	35	—	—	—	—
Dck/fr	167	3	6	—	130	—	2	30	—	—	—	—
Dck/fr	475	71	6	—	—	—	—	—	—	—	—	—
Dck/fr	168	31	6	—	—	8/67	20	—	—	—	—	—
Dck/fr	285	120	6	108, 237, 283	55	8/70	105	160	24	6	207	7.0
Dck/fr	337	81	6	320	200	9/67	10	130	—	—	—	—
MDp/fr	222	130	6	—	F	9/63	30	—	—	—	—	—
Dck/fr	545	31	6	—	—	9/64	1	—	—	—	—	—
Dck/fr	160	44	6	—	30	2/61	30	10	—	—	—	—
Dck/fr	120	35	6	—	60	11/64	20	40	—	—	—	—
Dck/fr	330	43	6	—	120	5/63	30	130	—	—	—	—
Dck/fr	313	40	6	—	140	3/59	40	60	—	—	—	—
Dck/fr	350	213	6	220, 340	200	5/67	8	50	—	—	—	—
Dck/fr	118	23	6	—	10	1960	6	80	1	—	283	6.6
MDp/fr	142	90	6	—	F	12/68	30	—	—	—	—	—
MDp/fr	189	14	6	—	F	1/69	10	—	—	—	—	—

Table 17

Well no.	Location no.	Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographi setting
Lk-111	4126-7542	West Mt. Sanitorium Well A	Cresswell Drilling Co.	1940	T	1720	W
112	4126-7542	West Mt. Sanitorium Well B	do.	1940	T	1730	W
113	4126-7542	Bozak, Steve	do.	1965	H	1330	S
114	4126-7542	Methot, Leon	do.	1968	H	1350	S
115	4127-7543	Heen, William	—	1969	H	1480	S
116	4123-7546	Grasso, Fred	Cresswell Drilling Co.	1969	H	1580	H
117	4125-7547	Ulrich, John	do.	1969	H	1140	H
118	4123-7546	Witman, James	George J. Reed & Son	1969	H	1600	H
119	4123-7548	Smith, John	Cresswell Drilling Co.	1966	H	910	S
120	4133-7537	Kazmierski, Bernard	do.	1967	H	1195	V
121	4133-7537	Corpus Christi Ch.	Tully Drilling Co., Inc.	1967	P	1210	V
122	4133-7532	Vosefski, Andrew	do.	1963	H	1650	S
123	4134-7533	Kopa, John	do.	1953	H	1740	H
124	4137-7532	Podhyski, Phillip	Philip W. Podhyski	1964	H	1710	S
125	4136-7533	Blue Ridge Motel, Orazzi	Tully Drilling Co., Inc.	—	P	1580	S
126	4135-7537	Edwards, Philip	Cresswell Drilling Co.	1966	H	1325	H
127	4135-7537	Matechak, Joseph	Tully Drilling Co., Inc.	1953	H	1260	S
128	4134-7536	Dennis, Gerald	William H. Wolfe	1967	H	1500	W
129	4134-7535	Harmony Heart Camp, D. Spurrier	Cresswell Drilling Co.	1958	P	1570	S
130	4134-7535	Shuman, J. E.	do.	1955	H	1570	S
131	4134-7535	Presty, Michael, Motel	Tully Drilling Co., Inc.	1948	P	1560	T
132	4136-7533	Finch Hill Farms, Inc.	Cresswell Drilling Co.	1963	P	1460	W
133	4132-7536	Chesar, Thomas	do.	1965	H	1560	S
134	4131-7536	Kapinus, Richard	George J. Reed & Son	1959	H	1380	S
135	4131-7536	Frazier, Joseph	Cresswell Drilling Co.	1957	H	1340	S
136	4131-7535	Oakley, William, Mrs.	do.	1960	H	1440	S
137	4131-7535	Andrini, Andrew, Rosemont Inn	Tully Drilling Co., Inc.	1959	P	1510	S
138	4133-7536	Schlasta, John	—	1940	H	1670	H
139	4131-7536	Koss, Andrew	Cresswell Drilling Co.	1960	H	1470	S
140	4131-7537	Gavlinski, Henry	do.	1959	H	1560	S
141	4131-7537	Sokolosky, Edward	do.	1962	H	1590	S
142	4133-7536	Lakeland Joint High Sch. Site	do.	1962	P	1680	H
143	4136-7532	Homestead Golf Course, PO Well	Fritz Brothers	1965	P	1620	S
144	4136-7532	Powell, Walter	—	1911	H	1550	V
145	4133-7536	Bianconi, Frank	—	1966	H	1590	H
146	4136-7533	McDonnel, Robert	Cresswell Drilling Co.	1962	H	1575	S
147	4137-7533	Monroe, George, Del Rocco Hotel	do.	1956	P	1720	H
148	4130-7537	Pish, Harry	do.	1961	H	1600	S
149	4131-7536	Scott View Golf Club	Tully Drilling Co., Inc.	1963	P	1610	H
150	4134-7539	Decker, Eugene	Cresswell Drilling Co.	1961	H	1100	W
151	4132-7536	Montdale Fire Co.	Tully Drilling Co., Inc.	—	F	1300	W
152	4131-7536	Montdale Methodist Ch.	do.	1958	H	1315	V
153	4130-7537	Golka, Anthony	Cresswell Drilling Co.	1960	H	1590	S
154	4130-7537	Romanovitch, Michael	do.	1961	H	1580	S
155	4132-7536	Zilla, S. J.	do.	1965	H	1370	S
156	4131-7536	Zelno, Stanley	do.	1961	H	1590	H
157	4132-7535	Dembert, S. E.	do.	1962	H	1640	T
158	4136-7532	Ross, Stuart	William H. Wolfe	1966	H	1575	S
159	4132-7535	Rinaldi, V. S.	Tully Drilling Co., Inc.	1964	H	1620	T
160	4133-7535	Martin, Edwin	Cresswell Drilling Co.	1958	H	1600	T
161	4133-7535	Feeney, Martin	do.	1956	H	1640	T
162	4132-7535	Fisher, Robert	do.	1955	H	1610	T
163	4132-7535	Nichols, Jack	do.	1957	H	1630	T
164	4130-7537	Novitski Garage	do.	1945	H	1540	W
165	4136-7533	Finch Hill Devlpmnt, Gasparini	—	—	P	1705	H
166	4134-7535	Wilmot, Reid	Tully Drilling Co., Inc.	1955	H	1655	H

Continued)

Aquifer/ lithology	Total depth below land surface (feet)	Casing Depth (feet)	Casing Diameter (inches)	Depth(s) to water-bearing zone(s) (feet)	Static water level Depth below land surface (feet)	Static water level Date measured	Pumping data Yield (gpm)	Pumping data DD (ft)	Pumping data Time (hr)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH
MDp/fr	430	200	8	—	10	—	70	350	—	—	137	6.8
MDp/fr	457	200	8	—	F	—	90	310	—	—	100	6.3
MDp/fr	208	60	6	—	F	9/65	6	175	—	—	—	—
MDp/fr	281	21	6	—	50	9/69	6	189	1	2	117	6.7
Dck/fr	400	38	6	—	114	8/69	8	—	—	—	—	—
Dck/fr	362	51	6	—	25	9/69	6	38	1	4	175	—
Dck/fr	310	101	6	—	226	9/69	6	10	1	7	250	—
Dck/fr	260	28	6	—	40	9/69	10	31	1	4	175	—
Dck/fr	420	25	6	—	335	9/69	8	39	1	4	503	—
Dck/fr	150	115	6	120, 140	40	6/67	12	60	—	—	—	—
Dck/fr	178	110	6	100,178	26	11/68	15	8	40	—	259	7.7
Pp/fr	150	40	6	—	F	11/68	50	10	—	—	86	6.5
Dck/fr	260	110	6	—	80	12/53	10	40	—	—	249	7.7
Dck/fr	130	69	6	—	25	3/64	25	30	—	—	316	7.5
Dck/fr	165	65	6	—	20	—	20	65	—	—	249	7.1
Dck/fr	275	20	6	—	160	8/66	4	90	—	—	—	—
Dck/fr	208	133	6	—	50	1953	9	100	—	—	—	—
Dck/fr	303	95	6	295	122	6/69	17	10	1	6	255	—
Dck/fr	194	24	8	—	35	7/69	8	17	1	6	270	—
Dck/fr	135	23	6	—	40	8/55	20	20	—	—	229	6.3
Dck/fr	145	40	6	—	10	—	20	70	—	5	260	—
Dck/fr	210	180	6	—	175	9/63	20	25	—	—	—	—
Dck/fr	240	60	6	—	192	5/65	20	28	—	—	—	—
Dck/fr	132	21	6	—	25	11/59	25	55	1	—	—	—
Dck/fr	35	20	6	—	25	—	20	5	—	—	—	—
Dck/fr	135	20	6	26	24	8/60	12	91	—	—	—	—
Dck/fr	198	45	6	—	8	6/59	40	50	—	—	—	—
Dck/fr	400	20	6	—	100	1940	20	85	—	6	198	—
Dck/fr	225	16	6	—	86	6/60	20	94	—	—	—	—
Dck/fr	150	23	6	—	40	12/59	30	20	—	—	—	—
Dck/fr	207	36	6	—	40	1/62	10	110	—	—	—	—
Dck/fr	595	61	10	220, 400, 475	306	7/69	55	50	24	—	215	7.5
Dck/fr	297	264	6	—	40	1965	20	110	2	—	—	—
Dck/fr	90	—	6	—	F	—	15	—	—	—	—	—
Dck/fr	100	20	6	—	30	—	25	—	—	—	—	—
Dck/fr	132	69	6	—	70	11/62	25	40	—	—	—	—
Dck/fr	395	75	6	—	300	12/56	15	50	—	—	—	—
Dck/fr	245	30	6	—	120	10/61	20	30	—	—	—	—
Dck/fr	360	18	6	—	180	8/63	45	70	2	—	—	—
Dck/fr	175	100	6	—	F	1961	15	—	—	—	671	9.4
Dck/fr	220	64	8	—	2	7/69	20	10	—	—	—	—
Dck/fr	123	68	6	—	3	11/58	40	17	—	—	—	—
Dck/fr	219	84	6	—	65	10/60	20	25	—	—	—	—
Dck/fr	220	71	6	—	70	9/61	20	30	—	—	—	—
Dck/fr	175	102	6	—	95	9/65	10	30	2	—	—	—
Dck/fr	316	31	6	—	205	1/61	10	45	—	—	—	—
Dck/fr	233	123	6	—	130	7/62	14	40	—	—	—	—
Dck/fr	134	59	6	130	50	10/66	20	40	2	—	—	—
Dck/fr	240	82	6	—	80	1964	8	100	—	—	—	—
Dck/fr	178	29	6	—	15	10/58	20	10	—	—	—	—
Dck/fr	175	69	6	—	60	4/56	20	40	—	—	—	—
Dck/fr	190	14	6	—	70	1955	30	30	—	—	—	—
Dck/fr	225	100	6	—	40	1957	20	70	—	—	—	—
Dck/fr	236	20	6	105	9	7/69	12	4	1	5	225	—
Dck/fr	488	—	8	—	—	—	50	—	—	—	—	—
Dck/fr	338	46	6	—	190	1955	15	75	—	—	—	—

Table 17

Well no.	Location no.	Owner	Driller	Date com-pleted	Use	Altitude of land surface (feet)	Topo-graphi setting
Lk-167	4134-7535	Wilmot, Robert	Cresswell Drilling Co.	1969	H	1665	H
168	4135-7534	Teeple, Michael	Tully Drilling Co., Inc.	1961	H	1670	H
169	4133-7542	Lysak, A. E.	Cresswell Drilling Co.	1967	H	1000	V
170	4135-7544	Talarico, S. C.	do.	1966	H	1205	S
171	4132-7544	Drake	do.	1967	H	970	W
172	4131-7539	Mathews, Clifford	do.	1967	H	1580	S
173	4131-7537	Grebowski, Joseph	do.	1968	H	1635	W
174	4130-7543	Graham, Robert	do.	1968	H	1060	V
175	4131-7543	Hartley, Franklin	do.	1967	H	1130	S
176	4131-7538	Cooper, William	do.	1967	H	1650	W
177	4130-7538	Justus Fire Co.	do.	1966	F	1460	W
178	4133-7539	Motel 81, Straka	do.	1962	P	1320	H
179	4133-7539	Straka, Joseph	George J. Reed & Son	1956	H	1180	V
180	4130-7542	Gorman, W. A., Jr.	Cresswell Drilling Co.	1966	H	1400	H
181	4130-7541	Strom, Margaret	do.	1967	H	1450	S
182	4131-7541	Nichols, Freda	do.	1967	H	1410	S
183	4130-7542	Lynn, Thomas, Abington Inn	do.	1951	P	1160	S
184	4135-7543	Carpenter, Joseph	do.	1954	H	1260	H
185	4130-7543	Plantholt, Lloyd, The Terrace	do.	1952	P	1150	S
186	4130-7542	Precision Engineering	do.	1956	P	1190	S
187	4131-7542	Labelle, Paul	do.	1964	H	1180	W
188	4131-7543	Glenburn Com. Center	—	1964	P	1100	S
189	4131-7543	Herman, Edward	Cresswell Drilling Co.	1964	H	1060	W
190	4131-7543	Stahl, William	do.	1964	H	1160	W
191	4131-7543	Catalano, Phillip	do.	1956	H	1100	W
192	4131-7544	Walsh, Robert	do.	1948	H	1040	S
193	4131-7544	Walters, William	do.	1955	H	1190	H
194	4132-7541	Von Storch, S. H.	do.	1967	H	1350	S
195	4132-7543	Breig, F. W.	do.	1960	H	1180	S
196	4132-7544	Sturdevant, J. C.	do.	1960	I	980	W
197	4132-7542	Trane, R. J.	do.	1961	H	1220	S
198	4132-7544	Palmiter, Irene	do.	1965	H	990	S
199	4134-7539	Tetto, Frank	do.	1961	H	1070	V
200	4134-7543	Kamp, Bockel	do.	1966	H	1210	S
201	4134-7543	Rudat, Mathew	do.	1947	H	1170	S
202	4135-7544	Kreitner, F. W.	do.	1953	H	1200	T
203	4135-7544	Horvath, George	do.	1952	H	1200	T
204	4135-7542	Fleetville Fire Co.	do.	1950	F	1230	S
205	4135-7542	Wademan, Charles	do.	—	H	1250	H
206	4135-7540	Clark, Merle	Tully Drilling Co., Inc.	1964	H	1290	H
207	4136-7544	Lakeland Golf Course, Powell	Cresswell Drilling Co.	1955	P	1160	W
208	4136-7544	Kolb, Harry	—	1959	H	990	T
209	4136-7544	Newheart, William	Cresswell Drilling Co.	1958	H	1030	W
210	4136-7543	Stark, Robert	do.	1963	H	1140	T
211	4136-7543	Leja, Emil	do.	1963	H	1140	T
212	4136-7542	Matylewicz, Joseph	do.	1956	H	1140	T
213	4136-7538	Worth Baptist Ch., Rev. Willis	do.	1963	P	1305	S
214	4136-7541	Price, Robert	do.	1956	H	1260	S
215	4130-7539	Heddon, Francis	do.	1962	H	1600	H
216	4135-7542	Atlantic Garage, H. H. Wells	do.	1937	H	1260	H
217	4134-7539	Decker, Eugene	George J. Reed & Son	1968	H	1100	W
218	4134-7538	Gasparini Club House	Tully Drilling Co., Inc.	—	R	1100	V
219	4132-7544	Hausler, Walter	Cresswell Drilling Co.	1961	H	1150	S
220	4132-7544	Davidson, George	do.	1963	H	930	V
221	4131-7544	Kramer, John	do.	1958	H	1000	W
222	4132-7544	Lower Dalton Well, Cl. Summit W. Co.	—	1907	P	980	V

Continued)

Aquifer/ lithology	Total depth below land surface (feet)	Casing Depth (feet)	Casing Diameter (inches)	Depth(s) to water-bearing zone(s) (feet)	Static water level Depth below land surface (feet)	Static water level Date measured	Pumping data Yield (gpm)	Pumping data DD (ft)	Pumping data Time (hr)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH
)ck/fr	285	20	6	—	220	8/69	6	7	1	5	227	—
)ck/fr	162	20	6	—	36	9/69	8	46	1	7	330	—
)ck/fr	125	80	6	110	F	8/67	15	15	—	—	—	—
)ck/fr	225	30	6	125, 200	155	9/66	25	45	2	—	—	—
)ck/fr	100	51	6	90	F	12/67	20	20	—	—	—	—
)ck/fr	200	41	6	150, 190	60	11/67	6	130	—	—	—	—
)ck/fr	615	31	6	350, 475	220	4/68	2	380	2	—	—	—
)ck/fr	165	70	6	150	30	3/68	40	40	—	—	—	—
)ck/fr	168	32	6	85, 160	30	9/67	20	70	—	—	—	—
)ck/fr	250	152	6	200, 235	145	7/67	25	55	—	—	—	—
)ck/fr	100	56	6	—	F	11/66	30	20	—	—	201	7.5
)ck/fr	233	228	6	230	150	4/62	15	70	—	—	310	—
)ck/fr	190	100	6	—	+3	7/69	30	—	—	—	219	8.1
)ck/fr	175	21	6	—	95	5/66	5	70	—	—	—	—
)ck/fr	314	40	6	—	250	9/67	10	50	—	—	—	—
)ck/fr	320	42	6	—	200	6/67	30	108	—	4	245	8.0
)ck/fr	188	69	6	—	60	1951	20	40	—	—	—	—
)ck/fr	230	110	6	200	75	8/54	20	35	—	—	—	—
)ck/fr	210	94	6	—	60	1952	8	80	—	—	—	—
)ck/fr	420	23	6	—	100	3/56	16	70	—	—	—	—
)ck/fr	237	26	6	—	20	2/64	35	100	—	—	—	—
)ck/fr	175	23	6	—	60	7/64	12	—	—	—	—	—
)ck/fr	330	32	6	—	80	1/64	40	70	—	—	—	—
)ck/fr	300	23	6	—	88	11/64	37	162	—	—	304	7.8
)ck/fr	199	91	6	—	40	1956	20	20	—	—	—	—
)ck/fr	145	75	6	—	50	1948	10	13	—	—	330	—
)ck/fr	275	117	6	250	200	8/55	10	40	2	—	—	—
)ck/fr	425	50	6	200	147	7/69	50	—	—	—	251	7.7
)ck/fr	333	44	6	—	120	6/60	20	30	—	—	—	—
)ck/fr	118	81	6	—	F	3/60	40	20	—	—	137	—
)ck/fr	307	30	6	—	120	8/61	40	30	2	—	—	—
)ck/fr	150	21	6	—	50	9/65	4	76	—	—	—	—
)ck/fr	125	67	6	—	F	9/61	40	40	—	—	—	—
)ck/fr	270	38	6	—	45	12/66	80	105	—	—	—	—
)ck/fr	235	135	6	—	45	1947	45	30	—	—	—	—
)ck/fr	165	64	6	—	20	1953	30	45	—	—	—	—
)ck/fr	166	43	6	—	22	10/68	30	58	2	5	253	—
)ck/fr	215	24	8	—	78	7/69	20	55	1	9	335	7.7
)ck/fr	190	47	6	—	65	12/61	20	30	—	—	—	—
)ck/fr	230	22	6	—	166	6/69	8	9	1	5	260	7.9
)ck/fr	294	37	6	—	130	1955	20	20	—	—	—	—
)ck/tr	150	70	6	—	20	1959	30	—	—	—	—	—
)ck/fr	145	72	6	—	40	1958	40	30	—	—	—	—
)ck/fr	200	35	6	—	40	4/63	15	120	2	—	—	—
)ck/fr	247	36	6	—	30	4/63	9	80	2	7	278	7.7
)ck/fr	120	30	6	20, 50	10	7/56	40	40	—	—	—	—
)ck/fr	195	46	6	—	104	6/69	4	20	1	7	289	7.7
)ck/fr	177	55	6	—	60	1956	25	30	—	—	—	—
)ck/fr	182	42	6	—	125	2/62	25	30	—	7	268	7.6
)ck/fr	150	0	—	—	58	10/68	10	—	—	—	294	7.4
)ck/fr	105	30	6	—	F	—	40	—	—	4	174	6.5
)ck/fr	140	106	6	—	+5	—	10	—	—	6	246	7.9
)ck/fr	316	24	6	—	178	7/69	7	100	—	5	240	7.3
)ck/fr	97	52	6	—	F	8/63	50	20	—	—	—	—
)ck/fr	160	37	6	—	14	2/69	40	15	—	—	—	—
)ck/fr	381	285	6	—	F	2/69	125	182	10	2	355	7.9

Table 1[illegible]

Well no.	Location no.	Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topo graph settin
Lk-223	4135-7538	Tompkins, Thelma	Cresswell Drilling Co.	1966	H	1140	S
224	4135-7538	El Rancho Adolphus	do.	1953	P	1330	H
225	4131-7544	Kramer, John & Hudak, M. J.	do.	1959	H	970	V
226	4132-7544	Cresswell, Grant	do.	—	H	990	W
227	4131-7544	Webster, Orson	do.	1940	H	990	V
228	4132-7544	A & B Gardens	—	1948	I	955	V
229	4131-7544	Gray, D. H.	Cresswell Drilling Co.	—	H	980	V
230	4131-7542	Waverly Water Co. Well 3	do.	1966	C	1260	W
231	4135-7544	Fogg, James	do.	1968	H	1190	S
232	4131-7542	Evans, B. F., Redevelopment	do.	1951	U	1190	W
233	4131-7542	Waverly Com. House	—	1919	R	1270	H
234	4131-7542	Dixon, Robert	Cresswell Drilling Co.	1967	H	1230	S
235	4133-7542	Tunkhannock Cr. State Pk. W1	do.	1969	P	1060	S
236	4132-7542	Sproul, Harvey	do.	1969	H	1260	H
237	4134-7542	White, J. R., Tunkhannock Cr. State Pk.	do.	1945	P	1000	W
238	4131-7542	Waverly Water Co. Well 2	William Stothoff Co.	1922	C	1260	S
239	4135-7539	General Electric	—	1900	H	1070	V
240	4135-7539	General Electric Well 3	Layne-New York Co., Inc.	1966	U	1070	V
241	4134-7539	General Electric Well 5	do.	1966	U	1070	V
242	4131-7543	Glenburn Water Co., W. Colombo	Tully Drilling Co., Inc.	1969	P	1200	H
243	4132-7545	Kline, Ben, Dr.	Cresswell Drilling Co.	1965	H	1100	S
244	4132-7545	Stee, E. G., M.D.	do.	1962	U	1160	S
245	4132-7545	Halstead, John	do.	1958	H	1200	S
246	4130-7545	Tarantini, P. A.	do.	1968	H	1230	V
247	4133-7546	Hazlett, Norman, Trailer Ct.	do.	1961	P	930	H
248	4137-7532	Orazzi, Dante	Tully Drilling Co., Inc.	1966	H	1650	T
249	4137-7537	Hanhauser, G. J., III	Cresswell Drilling Co.	1959	H	1380	S
250	4135-7534	Skyline Golf Course, Betrilak	Tully Drilling Co., Inc.	—	P	1670	S
251	4129-7540	Clarks Summit Water Co. Well 7	Moody Drilling Co., Inc.	1968	P	1280	W
252	4129-7540	Clarks Summit Water Co. Well 8	do.	1968	P	1170	W
253	4138-7531	Kerl, Thomas	Tully Drilling Co., Inc.	1968	H	1695	W
254	4138-7531	Cianflone, Anthony	do.	1964	H	1755	T
255	4138-7535	Clifford Fair Grounds Vol. Fire	William H. Wolfe	1960	P	1170	H
256	4138-7540	Gregus, Frank	Cresswell Drilling Co.	1966	S	1320	H
257	4137-7542	Duda, Ernie	William H. Wolfe	1969	H	1290	H
258	4129-7542	Clarks Summit Water Co. Well 1	Cresswell Drilling Co.	1957	C	1250	V
259	4132-7545	St. Pius X Seminary Well 1	do.	1961	P	1180	H
260	4128-7543	Country Club of Scranton Well 1	do.	1963	R	1520	H
261	4122-7533	St. Mary's Villa Poor Sisters	do.	1961	P	1550	S
262	4128-7543	Country Club of Scranton Well 4	do.	1968	R	1460	S
263	4134-7543	Koth, Jacob	do.	1964	H	1050	W
264	4136-7538	Peck, R. D.	William H. Wolfe	1967	H	1210	S
265	4130-7539	Lomeo, Samuel	Cresswell Drilling Co.	1967	H	1540	S
266	4133-7537	Bockousky, George	William H. Wolfe	1966	H	1350	S
267	4137-7540	Kordish, Edward	Ralph E. Myers	1969	H	1380	H
268	4130-7539	St. Gabriel's Convent	Cresswell Drilling Co.	1967	P	1570	H
269	4130-7543	Colombo Wellington Water Co.	Tully Drilling Co., Inc.	1968	P	1100	H
270	4130-7540	Peck, L. F.	do.	1967	H	1400	W
271	4126-7542	Patterson, R. O.	Cresswell Drilling Co.	1967	H	1340	S
272	4135-7531	Durso, Sam	Tully Drilling Co., Inc.	1961	H	1360	W
273	4136-7536	Hladick, Joseph	William H. Wolfe	1967	H	1510	S
274	4137-7537	Telep, Boris	do.	1966	H	1230	V
275	4131-7536	Black, James	do.	1966	H	1315	V
276	4134-7534	Taylor, Floyd	do.	1967	H	1470	W
277	4133-7534	Roberts, Sidney	do.	1967	H	1530	W
278	4137-7533	G & S Sales, Geroulo & Shalkey	Cresswell Drilling Co.	1969	I	1680	H

Continued)

Aquifer/ lithology	Total depth below land surface (feet)	Casing Depth (feet)	Casing Diameter (inches)	Depth(s) to water-bearing zone(s) (feet)	Static water level Depth below land surface (feet)	Static water level Date measured	Pumping data Yield (gpm)	Pumping data DD (ft)	Pumping data Time (hr)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH
Dck/fr	150	43	6	—	35	5/66	20	105	2	—	—	—
Dck/fr	520	22	8	—	213	1/69	100	136	—	—	179	6.8
Dck/fr	117	73	6	—	F	—	40	10	2	—	—	—
Dck/fr	186	60	8	—	F	—	100	100	—	—	—	—
Dck/fr	129	59	6	—	F	2/69	30	22	72	—	—	—
Dck/fr	82	6	6	—	F	—	8	—	—	—	—	—
Dck/fr	87	55	6	—	F	—	50	20	—	—	—	—
Dck/fr	600	200	10	590	95	10/66	175	71	24	6	310	7.5
Dck/fr	390	31	6	—	87	7/69	5	14	1	6	270	7.7
Dck/fr	576	20	10	100, 270, 420	16	7/69	21	6	1	—	292	7.7
Dck/fr	500	300	8	—	100	9/49	150	—	—	7	325	7.9
Dck/fr	250	91	6	240	175	5/67	8	50	2	7	255	—
Dck/fr	300	32	8	235, 284, 300	60	4/69	203	84	1	—	480	7.7
Dck/fr	299	50	6	—	70	6/69	100	110	1	—	—	—
Dck/fr	187	—	6	—	+10	—	20	—	—	8	330	7.5
Dck/fr	320	80	8	—	50	9/65	57	—	—	—	270	7.8
Qal/sd	16	0	—	—	13	10/68	5	—	—	3	95	6.7
Qal/sd	125	50	8	105	7	1/66	302	40	46	—	105	6.3
Dck/fr	323	80	8	124, 240, 283	F	1/66	230	174	46	—	1600	7.9
Dck/fr	320	21	6	—	137	9/69	50	25	—	—	—	—
Dck/fr	391	25	6	—	200	1/65	7	175	—	—	—	—
Dck/fr	575	20	6	555	185	8/62	4	115	—	6	257	6.9
Dck/fr	565	25	6	500	300	8/58	10	100	—	—	308	7.7
Dck/fr	315	31	6	196, 265	120	6/68	20	90	—	—	—	—
Dck/fr	203	20	6	—	50	8/61	30	20	—	—	—	—
Dck/fr	46	15	6	45	F	6/66	30	10	—	5	188	7.4
Dck/fr	286	17	6	—	185	1/59	15	45	—	—	—	—
Dck/fr	90	20	6	—	38	7/69	15	40	1	6	312	—
Dck/fr	376	58	8	178, 249, 270	29	8/69	200	120	24	4	250	7.5
Dck/fr	647	37	8	154, 186, 237	30	8/69	160	158	24	4	305	7.5
Dck/fr	118	62	6	114	25	2/68	30	15	—	3	118	7.3
Dck/fr	180	28	6	—	34	11/69	5	50	1	8	310	8.0
Dck/fr	210	85	6	—	32	9/69	20	25	1	3	215	—
Dck/fr	250	20	6	135, 235	73	9/69	8	10	1	7	302	—
Dck/fr	212	20	6	205	108	10/69	5	6	1	5	255	—
Dck/fr	565	76	10	90, 225, 335	8	7/57	352	80	48	—	—	—
Dck/fr	597	48	8	—	142	6/61	17	138	24	—	—	—
Dck/fr	568	213	8	320, 475, 550	165	2/63	150	60	24	—	—	—
Dck/fr	269	22	8	87,173,257	120	4/61	120	70	1	—	—	—
Dck/fr	400	43	8	120, 235, 380	120	9/68	125	155	2	—	—	—
Dck/fr	200	133	6	—	8	7/64	40	12	—	—	—	—
Dck/fr	104	30	6	100	30	4/67	20	30	2	—	—	—
Dck/fr	387	40	6	180,385	100	12/67	70	150	—	—	—	—
Dck/fr	260	30	6	170,260	140	12/66	15	35	2	—	—	—
Dck/fr	350	167	6	338	114	10/69	7	5	1	7	449	7.9
Dck/fr	425	42	8	400	211	1/69	8	200	24	—	—	—
Dck/fr	285	20	7	95, 145, 195	57	10/69	13	3	1	2	322	7.9
Dck/fr	160	22	7	—	35	10/67	6	70	—	—	—	—
MDp/fr	220	31	6	—	95	8/67	3	115	2	—	—	—
Dck/fr	145	70	6	130	—	2/70	15	—	—	6	265	7.9
Dck/fr	230	104	6	125,228	80	1/67	6	120	2	—	—	—
Dck/fr	215	58	6	140, 210	80	5/66	25	30	2	—	—	—
Dck/fr	117	57	6	115	3	11/66	30	25	2	—	—	—
Dck/fr	120	34	6	120	10	4/67	20	20	2	—	—	—
Dck/fr	140	76	6	136	10	3/67	30	20	2	—	—	—
Dck/fr	460	75	6	180, 455	242	10/69	10	200	—	—	—	—

Table 17

Well no.	Location no.	Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting
Lk-279	4126-7546	Hrobuchak, Joseph	George J. Reed & Son	1969	H	1000	W
280	4136-7541	Beichler, Earl	Cresswell Drilling Co.	1964	H	1310	S
281	4131-7543	Waverly Sewer Plant	do.	1969	Z	1095	V
282	4131-7543	Altieri, Gene	do.	1938	H	1130	W
283	4131-7543	White, M. L., Jr.	do.	—	S	1150	W
284	4135-7533	McDonnell's Grove, Robert McDonnell	—	—	P	1610	H
285	4135-7542	Green, Robert	Cresswell Drilling Co.	1966	H	1250	H
286	4129-7544	Clarks Summit State Hosp. Well 2	—	1918	T	1180	W
287	4129-7544	Clarks Summit State Hosp. Well 3	Sprague & Henwood, Inc.	1950	T	1240	W
288	4129-7544	Clarks Summit State Hosp. Well 4	do.	1950	T	1330	W
289	4138-7533	Pettinato, Vincent	William H. Wolfe	1969	H	1660	T
290	4135-7533	Sheridan, John	do.	1967	H	1610	H
291	4129-7544	Sarno, Lawrence	Cresswell Drilling Co.	1967	H	1280	S
292	4130-7543	Wilverding, George	do.	1966	H	1070	W
293	4132-7544	Strom, Garfield	do.	1966	H	970	W
294	4134-7544	Antoine, Donald	do.	1966	H	980	W
295	4130-7537	James, Frank	do.	1966	H	1580	S
296	4130-7537	White, Aldon	do.	1966	H	1580	S
297	4130-7538	Zowacki, Walter	do.	1967	H	1500	W
298	4131-7538	Evans, F. P.	do.	1966	H	1490	V
299	4135-7540	Pensak, Ronald	do.	1966	H	1190	S
300	4119-7533	Burnett, J.	Fritz Brothers	1969	H	1460	V
301	4123-7527	Arnold, Mort	Cresswell Drilling Co.	1969	H	1460	V
302	4116-7530	Nowalk, Robert	Fritz Brothers	1969	H	1875	S
303	4122-7533	Ward, Genevieve	Cresswell Drilling Co.	1961	H	1380	V
304	4120-7528	Wallick, John	—	1965	H	1860	S
305	4118-7528	Szymanosky, Chester	Robert Wayne Knight	1966	H	1845	S
306	4118-7531	Fell, William	—	1969	H	1845	S
307	4117-7530	Price, D. G.	Robert Wayne Knight	1969	H	1825	S
308	4117-7534	Morgan, Art	do.	1967	S	1635	S
309	4119-7532	Smith, William	do.	1967	H	1760	S
310	4120-7531	Skelton, Ralph	—	1967	H	1530	S
311	4124-7528	Mission Retreat Fellowship	Robert Wayne Knight	1968	H	1600	S
312	4120-7532	Sekely, Paul	do.	1967	H	1730	S
313	4118-7532	Lindner, George	do.	1967	H	1805	S
314	4125-7549	Kenia, William	Cresswell Drilling Co.	1970	H	1050	H
315	4113-7532	Miners Mills Sporting Club	Robert Wayne Knight	1966	H	1620	V
316	4118-7528	Puchalski, Vincent	do.	1966	H	1825	S
317	4119-7533	Van Brunt, Elmer	do.	1969	C	1700	V
318	4120-7531	Pocono Joint Sch. Dist.	Tully Drilling Co., Inc.	1967	T	1700	S
319	4127-7528	Castellitto, Joe	Fritz Brothers	1969	H	1640	S
320	4120-7535	Roaring Brook Estates 1	Robert Wayne Knight	1968	P	1640	S
321	4120-7534	Roaring Brook Estates 2	Fritz Brothers	1965	P	1670	S
322	4121-7533	Olwen Hts. Water Co. 1	do.	1962	P	1650	S
323	4121-7533	Olwen Hts. Water Co. 2	—	1962	P	1710	S
324	4121-7532	Olwen Hts. Water Co. 3	Fritz Brothers	1962	P	1690	S
325	4121-7534	Elmbrook Terrace	—	1965	P	1700	S
326	4120-7536	Melashevsky	—	1954	H	1650	S
327	4117-7532	Legg, Ronald	Robert Wayne Knight	1967	H	1815	H
328	4117-7532	Jewish Com. Center	do.	1965	T	1790	S
329	4119-7528	Frey, Charles	Fritz Brothers	1965	H	1845	S
330	4120-7531	Hafner, Glenn	—	1960	H	1755	S
331	4123-7528	Eib, Myrta	Cresswell Drilling Co.	1958	H	1580	V
332	4119-7528	Kohut, Carl	—	1956	H	1870	H
333	4120-7533	Sevensky, Stephen	Cresswell Drilling Co.	1958	H	1780	S
334	4119-7534	Genett, Frank	do.	1966	H	1725	S

(Continued)

Aquifer/ lithology	Total depth below land surface (feet)	Casing Depth (feet)	Casing Diameter (inches)	Depth(s) to water-bearing zone(s) (feet)	Static water level Depth below land surface (feet)	Static water level Date measured	Pumping data Yield (gpm)	Pumping data DD (ft)	Pumping data Time (hr)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH
Dck/fr	197	20	6	—	34	10/69	12	5	1	—	—	—
Dck/fr	175	22	6	—	80	6/64	25	20	2	—	—	—
Dck/fr	240	62	6	—	12	11/69	34	39	24	8	327	7.8
Dck/tr	190	90	6	—	23	11/69	5	4	1	4	207	—
Dck/fr	260	—	6	—	86	11/69	20	40	1	7	342	—
Dck/fr	194	77	8	—	6	11/69	15	3	1	4	170	—
Dck/fr	325	20	6	220, 315	160	7/66	25	20	2	—	—	—
Dck/fr	310	75	8	—	—	—	100	—	—	—	—	—
Dck/fr	400	170	10	—	220	—	240	120	—	—	—	—
Dck/fr	400	170	10	—	300	—	240	20	—	—	—	—
Dck/fr	143	22	6	90, 140	70	3/69	15	10	2	—	—	—
Dck/fr	140	77	6	136	45	9/67	20	20	2	—	—	—
Dck/fr	165	40	6	140	80	7/67	35	45	2	—	—	—
Dck/fr	88	20	6	75	F	9/66	50	50	2	—	—	—
Dck/fr	112	20	6	90	F	8/66	60	40	2	—	—	—
Dck/fr	175	124	6	140, 170	F	9/66	80	10	2	—	—	—
Dck/fr	250	107	6	156, 235	100	6/66	10	80	2	—	—	—
Dck/fr	320	61	6	210, 305	85	11/66	6	215	2	—	—	—
Dck/fr	420	20	6	320, 400	135	1/67	60	140	2	—	—	—
Dck/fr	125	31	6	90	6	11/66	7	24	2	—	—	—
Dck/fr	256	31	6	140, 220	80	11/66	30	50	2	—	—	—
Dck/fr	190	62	5	—	71	7/69	7	27	1	4	157	—
Dck/fr	236	40	6	—	16	10/69	9	42	1	6	212	—
Dck/fr	162	85	5	132	59	6/69	5	12	1	2	90	—
Dck/fr	119	20	6	—	28	6/69	8	22	1	—	—	—
Dck/fr	200	30	6	—	100	12/65	6	75	—	—	—	—
Dck/fr	155	60	6	120, 149	40	10/66	8	—	—	—	—	—
Dck/fr	175	41	5	—	15	6/69	4	—	—	—	—	—
Dck/fr	82	27	6	—	13	6/69	7	12	1	5	200	—
Dck/fr	155	114	6	120, 131	40	8/67	28	—	—	—	—	—
Dck/fr	223	21	6	220	63	5/69	55	1	—	—	—	—
Dck/fr	140	92	6	—	45	7/67	20	—	—	—	—	—
Dck/fr	222	21	6	120, 180, 210	46	3/68	16	—	2	4	175	—
Dck/fr	98	65	6	80, 92	32	5/67	11	—	—	—	—	—
Dck/fr	105	44	6	52, 72, 100	47	4/67	30	—	—	—	—	—
Dck/fr	410	40	6	173	170	11/70	2	—	—	—	—	—
Dck/fr	158	19	6	154	9	6/66	100	—	—	—	—	—
Dck/fr	155	54	6	150	—	9/66	20	—	—	—	—	—
Dck/fr	365	51	6	63, 157, 236	28	7/69	12	31	1	—	—	—
Dck/fr	400	—	8	210	42	10/67	39	258	48	—	—	—
Dck/fr	136	67	5	136	—	6/69	20	—	—	—	—	—
Dck/fr	198	125	6	—	16	4/70	27	5	1	6	225	7.0
Dck/fr	413	63	6	310, 358, 420	100	—	5	293	24	4	—	7.3
Dck/fr	255	40	5	—	26	—	110	50	—	—	—	—
Dck/fr	169	—	—	—	—	—	60	—	—	—	—	—
Dck/fr	369	40	6	110, 183, 270	69	—	45	280	—	—	—	—
Dck/fr	225	110	6	—	92	—	40	—	—	—	—	—
Dck/fr	180	120	6	—	15	—	15	—	—	—	—	—
Dck/fr	84	75	6	80	F	9/67	20	—	—	—	—	—
Dck/fr	283	85	6	185, 212, 262	65	6/65	18	245	12	—	—	—
Dck/fr	132	46	5	—	60	1965	7	62	—	—	—	—
Dck/fr	175	35	6	—	45	1960	6	—	—	—	—	—
Dck/fr	80	53	6	—	40	10/58	50	60	—	—	—	—
Dck/fr	160	—	—	—	60	1956	—	40	—	—	—	—
Dck/fr	170	—	—	—	40	12/58	30	40	—	—	—	—
Dck/fr	260	50	6	160, 230	50	7/66	12	170	4	—	—	—

Table 17.

Well no.	Location no.	Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting
k-335	4123-7528	Simons, Anthony	Fritz Brothers	1967	H	1600	S
336	4117-7530	Koch, Ernie	Paul's Drilling Co.	1966	H	1915	S
337	4119-7534	Sposto, Enrico	Robert Wayne Knight	1968	H	1730	S
338	4117-7530	McGuire, Robert	Paul's Drilling Co.	1966	H	1910	S
339	4114-7530	Colliers, Edgar	Fritz Brothers	1967	H	1775	V
340	4118-7537	Davitt, K. J.	Cresswell Drilling Co.	1969	H	1510	S
341	4127-7528	Catania, Charles	Tully Drilling Co., Inc.	1969	H	1680	S
342	4117-7526	Bentler, William	Robert Wayne Knight	1969	H	1940	S
343	4112-7533	Rudge, C. N.	Ralph E. Myers	1969	H	1580	V
344	4118-7537	Lamberti, Nicholas	Cresswell Drilling Co.	1968	H	1510	S
345	4114-7530	Gable, John	—	1964	H	1805	V
346	4114-7530	Gable, John	Robert Wayne Knight	1966	P	1830	V
347	4120-7532	Sekely, John	—	1946	H	1725	S
348	4118-7533	Lewis, Ruth	Cresswell Drilling Co.	1958	H	1710	S
349	4118-7533	Wysocki, William	do.	1958	H	1730	S
350	4122-7532	Chicco, Carmen	do.	1957	H	1460	S
351	4120-7531	Matchulat, Donald	do.	1959	H	1565	S
352	4118-7530	Daleville Methodist Ch.	do.	1955	P	1835	S
353	4120-7531	North Pocono Joint Sch.	Robert Wayne Knight	1966	P	1620	S
354	4122-7532	Ferraldo, Paul	—	1960	H	1460	S
355	4116-7527	Ames, Dorothy	—	1964	H	1900	L
356	4126-7530	Muldoon, Anthony	Cresswell Drilling Co.	1966	H	2040	L
357	4121-7529	Snyder, Edward	do.	1956	H	1610	H
358	4123-7527	Meruri, John	Jack Ziegler	1966	H	1420	S
359	4117-7531	Internat. Salt Co.	—	1966	N	1900	S
360	4120-7535	Schweiter, E. F.	Cresswell Drilling Co.	1955	H	1665	S
361	4118-7536	Eaton, Leroy	Fritz Brothers	1964	H	1430	S
362	4117-7532	Eureka Stone Quarry	Charles Lauman	1968	N	1900	S
363	4124-7531	Ognasky, John	Cresswell Drilling Co.	1967	H	1500	L
364	4125-7531	Rodgers, F. E.	do.	1965	H	2010	L
365	4115-7530	Hicks, Howard	Robert Wayne Knight	1969	H	1830	S
366	4118-7535	Eglisha, Joseph	Fritz Brothers	1969	H	1510	S
367	4121-7529	Whymeyer, Gus	—	1969	H	1610	V
368	4119-7531	Kramer, Lester	—	1967	H	1750	H
369	4125-7529	Abda, James	—	1969	H	1620	S
370	4137-7542	Robbins, W. P.	Cresswell Drilling Co.	1966	H	1270	H
371	4137-7541	Robinson, Donald	do.	1966	H	1270	H
372	4133-7535	Terry, Buddy	do.	1966	H	1620	S
373	4133-7535	Roba, Joseph	do.	1966	H	1435	W
374	4127-7544	Sponaugle, I. J.	do.	1966	H	1300	W
375	4129-7543	Clarks Summit Meth. Ch.	do.	1966	P	1480	H
376	4129-7539	Detty, Howard	do.	1966	H	1570	H
377	4129-7540	White, J. N.	do.	1966	H	1340	S
378	4134-7540	Garvey, John	do.	1970	H	1170	W
379	4131-7545	Catalano, Paul	do.	1965	H	1180	S
380	4131-7546	Lieber, Stanley	do.	1965	H	1020	V
381	4131-7545	Northrup, Morris	do.	1969	H	1140	C
382	4130-7543	Brace, Emerson, Angelo's Restaur.	—	1946	P	1060	V
383	4130-7543	Shurtleff, Richard	Cresswell Drilling Co.	1968	H	1080	S
384	4134-7540	Cook, Robert	do.	1970	H	1100	C
385	4135-7541	Spencer, C. P.	—	1957	H	1010	V
386	4135-7542	Edwards Bros. Meat Pkng. Co. 1	Tully Drilling Co., Inc.	1970	N	1310	S
387	4135-7542	Edwards Bros. Meat Pkng. Co. 2	do.	1970	N	1290	S
388	4135-7542	Edwards Bros. Meat Pkng. Co. 3	do.	1970	N	1280	S
389	4536-7543	Edwards Bros. Meat Pkng. Co. 4	do.	1970	N	1290	H
390	4118-7529	Pa. Gas and Water Co.	Cresswell Drilling Co.	1967	Z	1635	C

Continued)

Aquifer/ lithology	Total depth below land surface (feet)	Casing Depth (feet)	Casing Diameter (inches)	Depth(s) to water-bearing zone(s) (feet)	Static water level Depth below land surface (feet)	Static water level Date measured	Pumping data Yield (gpm)	Pumping data DD (ft)	Pumping data Time (hr)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH
Dck/fr	143	41	5	—	69	9/69	15	7	1	4	197	—
Dck/fr	227	11	6	180, 219	90	7/66	4	—	—	—	—	—
Dck/fr	103	77	6	85	36	—	15	—	—	—	—	—
Dck/fr	178	16	6	151, 176	40	12/66	7	—	—	—	—	—
Dck/fr	120	75	5	—	8	1967	30	42	—	—	—	—
Dck/fr	143	40	6	—	91	9/69	20	30	1	4	175	—
Dck/fr	240	52	6	—	42	9/69	7	100	1	2	103	—
Dck/fr	150	27	6	—	69	10/69	6	18	1	2	68	—
Dck/fr	70	35	6	—	8	10/69	8	2	1	4	177	—
Dck/fr	388	51	6	—	139	10/69	1	52	1	—	—	—
Dck/fr	98	82	6	—	10	3/64	60	—	—	—	—	—
Dck/fr	155	124	6	135, 150	40	8/66	60	—	—	—	—	—
Dck/fr	130	60	—	—	15	—	—	—	—	—	—	—
Dck/fr	100	60	6	—	25	—	45	35	—	—	—	—
Dck/fr	98	54	6	—	15	7/58	25	10	—	—	—	—
Dck/fr	133	18	6	—	75	6/57	20	30	—	—	—	—
Dck/fr	124	45	6	—	50	4/59	20	20	—	—	—	—
Dck/fr	164	130	6	—	50	—	20	50	—	—	—	—
Dck/fr	360	206	6	—	200	4/66	60	10	1	—	—	—
Dck/fr	80	34	6	—	—	—	6	—	—	—	—	—
Dck/fr	95	17	6	—	30	10/64	30	—	—	—	—	—
Dck/fr	200	81	6	175	105	7/66	10	35	2	—	—	—
Dck/fr	157	104	6	—	80	9/56	15	40	—	—	—	—
Dck/fr	168	47	5	24, 165	35	9/66	20	—	—	—	—	—
Dck/fr	140	30	6	—	—	—	25	—	—	—	—	—
Dck/fr	210	100	6	—	70	1/55	10	50	—	5	184	7.5
Dck/fr	110	32	5	—	20	—	25	55	—	—	—	—
Dck/fr	186	20	6	—	70	5/68	61	90	6	—	—	—
Dck/fr	167	62	6	167	90	9/67	20	60	2	—	—	—
Dck/fr	200	100	6	—	80	10/65	14	45	—	—	—	—
Dck/fr	180	21	6	50, 170	31	5/70	6	75	1	2	105	—
Dck/tr	107	98	5	107	56	10/69	11	3	1	2	87	—
Dck/fr	110	29	6	—	25	6/69	20	—	—	—	—	—
Dck/fr	213	32	6	—	110	9/67	8	82	2	—	—	—
Dck/fr	200	17	6	—	—	—	1	—	—	—	—	—
Dck/fr	460	30	6	275, 410	375	6/66	10	30	2	—	—	—
Dck/fr	300	31	6	220, 280	60	11/66	30	230	2	—	—	—
Dck/fr	208	65	6	110, 200	100	8/66	8	70	2	—	—	—
Dck/fr	65	50	6	60	5	7/66	30	15	2	—	—	—
Dck/fr	155	51	6	105, 140	65	8/66	20	45	2	—	—	—
Dck/fr	475	42	6	350, 440	200	11/66	7	250	4	—	—	—
Dck/fr	250	130	6	240	105	7/66	8	115	2	—	—	—
Dck/fr	173	20	6	150	60	10/66	10	80	2	—	—	—
Dck/fr	255	200	6	255	116	1/70	100	4	—	—	319	7.2
Dck/fr	415	20	6	—	100	3/65	1	200	2	—	—	—
Dck/fr	133	48	6	25, 40	21	3/70	50	—	—	—	—	—
Dck/fr	263	50	6	260	70	11/69	6	165	1	—	—	—
Dck/tr	73	45	6	—	+30	1946	45	—	—	—	—	—
Dck/fr	157	44	6	—	120	1/20	50	20	2	—	—	—
Dck/fr	210	165	6	—	60	2/70	60	30	1	—	—	—
Dck/fr	110	42	6	—	F	11/57	40	—	—	—	—	—
Dck/fr	450	21	6	128, 191, 268	155	3/70	46	70	1	9	325	7.4
Dck/fr	545	81	8	82, 179, 190	180	4/70	160	190	1	7	353	7.3
Dck/fr	500	30	8	61, 145, 251	151	4/70	223	152	1	7	304	7.5
Dck/fr	515	20	6	300, 400, 515	180	5/70	75	—	—	—	—	—
Qal/sd	35	25	6	20	7	2/67	163	19	44	—	—	—

Table 17.

Well no.	Location no.	Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting
k-391	4118-7529	Pa. Gas and Water Co.	Cresswell Drilling Co.	1967	Z	1632	C
392	4136-7540	Delevan, H. C.	do.	1964	H	1290	W
393	4130-7542	Glen Oaks Country Club	do.	1953	R	1210	S
394	4130-7542	Clarks Summit Water Co. Well 5	do.	1953	P	1220	S
395	4130-7542	Hilwig, Fred, Mrs.	do.	1955	H	1170	S
396	4130-7542	Wright, Waldo	—	—	H	1140	S
397	4121-7536	Smith, Robert	Cresswell Drilling Co.	1955	H	1695	S
398	4138-7533	Mancuso, Frank	William H. Wolfe	1969	H	1650	T
399	4134-7535	Cheybosky, Basil	Tully Drilling Co., Inc.	1966	H	1585	S
400	4133-7536	Diblasi, Antonio	do.	1967	H	1615	S
401	4136-7542	Darling, Paul	do.	1965	H	1190	S
402	4136-7542	Darling, Sarah	do.	1966	H	1170	S
403	4128-7537	Parrish Diner, Clare Kane	—	1965	P	1210	S
404	4130-7542	Waverly Sewer Plant 2	—	1970	Z	1110	V
405	4132-7543	Fuller, M. B.	Cresswell Drilling Co.	1930	H	1110	V
406	4123-7535	Pa. Gas and Water Co.	—	—	P	1129	V
407	4123-7535	Pa. Gas and Water Co.	—	—	P	1131	V
408	4129-7540	Stanton Water Co.	—	1963	P	1315	V
409	4128-7540	Hall Water Supply Co.	—	1964	P	1230	S
410	4129-7540	Marshal Water Supply Co.	—	—	P	1400	V
411	4133-7541	Sunset Hills Water Co.	—	1963	P	1170	S
						SUSQUEHANNA	
Sq-60	4138-7531	Gallagher, William	Cresswell Drilling Co.	1967	H	1790	S
61	4138-7535	Carr, Clarence	do.	1965	H	1120	S
62	4138-7540	Belack, William	do.	1954	S	1300	H
							WAYNE
Wn-65	4122-7526	Klim, Michael	Cresswell Drilling Co.	1966	H	1570	S
						WYOMING	
Wy-61	4133-7546	Langford, Richard	Cresswell Drilling Co.	1962	H	980	H
62	4133-7546	Sherwood, Kenneth	do.	1966	H	970	S
63	4135-7546	Factoryville Water Supply Well 1	do.	1969	P	1000	W
64	4133-7546	Derr, Harry, Jr.	do.	1969	H	910	W
65	4135-7546	Factoryville Water Supply, Lomma Well 2	do.	1970	P	910	V

Spring no.	Location no.	Owner	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/ lithology	Yield (gpm)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH
k-Sp-1	4133-7533	Zaleski	H	1710	S	Dck/fr	4	1	65	5.9
2	4126-7542	West Mountain Sanitorium	P	1855	T	MDp/fr	15	1	38	5.9
3	4120-7534	Roaring Brook Estates	U	1640	S	Dck/fr	2	—	45	—

Continued)

Aquifer/ lithology	Total depth below land surface (feet)	Casing Depth (feet)	Casing Diameter (inches)	Depth(s) to water-bearing zone(s) (feet)	Static water level Depth below land surface (feet)	Static water level Date measured	Pumping data Yield (gpm)	Pumping data DD (ft)	Pumping data Time (hr)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH
Qal/sd	29	19	6	20	5	2/67	30	8	2	—	—	—
Dck/fr	190	103	6	—	90	12/64	15	50	—	—	—	—
Dck/fr	606	45	10	—	100	10/69	138	200	—	—	—	—
Dck/fr	620	90	10	57,100,205	220	9/53	110	33	2	—	—	7.0
Dck/fr	165	20	6	—	62	6/70	15	—	—	10	775	7.2
Dck/fr	110	14	6	—	51	6/70	20	—	—	—	—	—
Dck/fr	190	35	6	—	10	12/69	20	20	1	4	123	—
Dck/fr	156	82	6	130, 156	30	5/69	20	30	2	—	—	—
Dck/fr	133	40	6	130	50	11/66	20	75	—	—	—	—
Dck/fr	245	55	7	240	70	2/67	15	110	—	—	—	—
Dck/fr	140	100	6	—	20	1965	20	10	—	—	—	—
Dck/fr	118	100	6	—	F	1966	20	6	2	—	—	—
Pp/fr	600	500	5	—	350	—	40	—	—	—	—	—
Dck/fr	235	123	6	—	7	9/70	24	3	1	—	—	—
Dck/fr	417	40	8	142, 253, 295	120	10/30	105	44	—	—	—	—
Dck/fr	455	20	8	—	F	6/71	—	—	—	—	—	—
Dck/fr	1000	20	10	—	F	6/71	—	—	—	—	—	—
Dck/fr	250	133	8	—	80	—	35	—	24	—	—	—
Dck/fr	270	31	6	—	75	—	20	50	—	—	—	—
Dck/fr	—	—	—	—	—	—	15	—	—	—	—	—
Dck/fr	168	109	8	—	40	—	100	30	—	—	—	—
COUNTY												
Dck/fr	168	92	6	140	60	11/67	37	80	—	—	301	7.7
Dck/fr	124	44	6	—	10	5/65	30	30	—	—	—	—
Dck/fr	408	21	8	—	190	11/69	12	70	—	—	—	—
COUNTY												
Dck/fr	135	115	6	125	60	11/66	7	65	2	—	—	—
COUNTY												
Qgog/bt	212	200	6	200	122	10/69	5	29	1	6	234	—
Dck/fr	300	223	6	150, 200, 300	150	10/66	35	—	—	—	—	—
Dck/fr	330	41	6	315	85	8/69	12	3	1	3	290	8.7
Dck/fr	195	120	6	190	81	3/69	14	13	2	4	275	7.7
Dck/fr	183	43	6	55, 130, 155	11	3/70	20	3	1	5	278	—

Table 18. *Sample Logs of Wells in the Catskill Formation*

Well Lk-89

Owner: U.S. Geological Survey
Altitude: 1,130
Driller: Cresswell Drilling Co.
Drilled: 1970
Static water level: 43 ft
Reported yield: 102 gpm

Description	Thickness (feet)	Depth (feet)
Boulder gravel, sand, silt, and clay; yellow-gray decomposed basement rock; soil zones	7	0– 7
Sandstone, yellow, very fine to medium-grained; weathered rock	3	7– 10
Siltstone, red, interbedded red shale and yellow fine-grained sandstone	5	10– 15
Shale, red, interbedded reddish-brown siltstone	5	15– 20
Sandstone, grayish-green, fine- to medium-grained; interbedded gray siltstone	8	20– 28
Sandstone, light-gray, fine- to medium-grained; gray interbedded shale with pyrite; slaty cleavage; fractured rock with small amount of mica; 1 gpm of water	4	28– 32
Siltstone, light- to dark-gray, variegated red and gray shale partings, fissile, micaceous; contains quartz porphyroblasts	13	32– 45
Sandstone, light- to medium-gray, fine-grained, uniform grain size, massive, very hard with silica cement	6	45– 51
Siltstone, medium- to dark-gray, uniform grain size, very slaty and hard	4	51– 55
Sandstone, reddish-brown, green, and gray, variegated, very fine to fine-grained; conchoidal fracture; calcareous cement; thin interbedded siltstone, micaceous; pyritic near bottom; fracture zone; water course—3 gpm at 57 ft	12	55– 67
Sandstone, light-gray, medium-grained, thin-bedded, micaceous; black mineralization; water level 27 ft below land surface datum	3	67– 70
Siltstone, brown to dark-grayish-green; very micaceous, brown; light-gray to white, medium- to large-grained quartz pebbles, weathered zone with pyrite, iron stains; fracture zone	4	70– 74
Sandstone, greenish-gray, fine- to medium-grained; silty, fissile, soft, friable; porous, weathered surfaces along fracture, black stain; pyrite, large muscovite crystals at bottom; calcareous; water course—30 gpm at 77 ft	11	74– 85
Sandstone, medium- to dark-gray, medium-grained; contains dark-gray to black rock fragments of shale and siltstone; large crystals of calcite vein materials; iron stain; many fractures partly filled with calcite	3	85– 88
Shale, black, silty, fissile, friable	1	88– 89
Sandstone, dark-gray to black grading to light-gray to green; fine grained grading to medium grained; fractured surfaces with iron stains, very calcareous; friable; silty; weathered, oxidized zones with much calcite vein material near bottom; water course—8 gpm at 91 ft	11	89–100

Table 18. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Siltstone, gray-green to brown; interbedded mudstone, slightly calcareous; some oxidized zones with iron stains; light-gray-green, fine- to medium-grained sand near bottom	10	100–110
Sandstone, light-gray, medium-grained; dark-gray to reddish-brown interbedded siltstone; small amount of mica; friable, distinct bedding planes	13	110–123
Siltstone, dark-gray, some fissility, micaceous	4	123–127
Sandstone, light-gray, fine-grained; shale partings with some fissility; small amount of pyrite, small amount of mica; slightly calcareous	7	127–134
Shale, medium-gray, silty, fissile, slightly calcareous, small amount of mica; some pyrite and iron staining; oxidized zone	4	134–138
Sandstone, reddish-brown grading to medium- to dark-gray, fine- to medium-grained; silty and slightly fissile; calcite vein material; small amount of mica; very hard	12	138–150
Sandstone, medium-gray, medium-grained, massive, dense; some vein calcite; small amount of mica	10	150–160
Sandstone, light-gray, fine- to medium-grained; interbedded gray-green shale; distinct bedding planes (thin-bedded) breaking across fissility with conchoidal fracture; finely disseminated black mineral; calcareous; fracture zone; water course—10 gpm at 163 ft	10	160–170
Sandstone, light- to medium-gray, fine-grained grading to medium- and coarse-grained; massive ledge rock near top grading to carbonaceous lenses near bottom; silty and shaly; micaceous; coal fragments; much calcite vein material with pyrite (good cubic faces); water level—59 ft below land surface datum	15	170–185
Siltstone, variegated gray-green; interbedded shale; thinly laminated with streaks of interbedded pyrite	5	185–190
Sandstone, light-gray grading to greenish-gray, medium- to coarse-grained; hard, massive with distinct laminations; pyritic, calcareous and slightly vuggy with calcite crystals	28	190–218
Sandstone, dark-gray, very fine grained, silty; lenticular, slaty cleavage; very micaceous; fossil wood and coal fragments	2	218–220
Sandstone, light-gray to green, medium- to coarse-grained; very hard; calcite veins, coarse mica flakes; black mineral, more vein material and possible slickensides near bottom; fracture zone; water course —30 gpm at 230 ft	16	220–236
Siltstone, medium- to dark-gray, interbedded shale and coarse-grained sand; green claystone near bottom with slickensides; highly fissile, much pyrite and very limy; coarse-grained mica; fracture zone	14	236–250
Sandstone, dark-gray, fine- to medium-grained, medium-gray, silty, micaceous; indistinct bedding planes with little fissility	5	250–255
Siltstone, dark-green and gray; very shaly; thin laminations and crossbedding; dark mineralization and finely disseminated pyrite; calcareous and micaceous	11	255–266
Sandstone, light-gray, medium-grained; more calcareous and shaly (black) near bottom; thin coal lense at 278 ft; some mica; fracture zone	17	266–283

Table 18. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Sandstone, medium- to dark-gray, medium- to coarse-grained; dark-gray sandstone is silty and shaly; very hard with indistinct bedding planes; thin shale partings and coal fragments at bottom; very calcareous; coarse mica crystals; fracture zone	7	283–290
Sandstone, light- to medium-gray, fine- to medium-grained, very shaly and limy; large calcite fragments; alternating gray sand and shale near bottom; finely micaceous; very calcareous; water course—25 gpm at 293 ft; H_2S odor; water level 63 ft below land surface datum	10	290–300

Well Lk-99

Owner: Roaring Brook Estates Well No. 3
Altitude: 1,670
Driller: Cresswell Drilling Co.
Drilled: 1970
Static water level: 55 ft
Reported yield: 129 gpm prior to grouting upper zone

Description	Thickness (feet)	Depth (feet)
Landfill and soil; sand, silt, and clay	10	0– 10
Boulder gravel, sand, silt, glacial debris	28	10– 38
Shale, red, silty; weathered and soft; old surface zone	4	38– 42
Siltstone, red, shaly; massive with interbedded shale, very micaceous, fine-grained	15	42– 57
Siltstone, brown, sandy; shale interbeds, micaceous and weathered; black mineral coating fractured rock fragments	3	57– 60
Siltstone, dark red, shaly; micaceous along distinct bedding planes; shale soft; breaks across bedding	10	60–70
Shale, light-red, silty as above; little mica, flakes larger at bottom; soft, friable, balls up when wet	15	70– 85
Sandstone, light-red, silty, fine- to coarse-grained, contains green translucent grains of calcite; large brown mica flakes; rock breaks along calcite veins	15	85–100
Sandstone, brown, fine- to medium-grained; iron stain along fractured rock; variegated red and gray; black coating on rock fragments; weathered pyrite zones; chloritic with large mica flakes; primary solution porosity; water course—2 gpm	5	100–105
Shale, green-brown; soft, balls up when wet; green crystals of calcite; fibrous, clear crystals of selenite	3	105–108
Sandstone, medium- to dark-gray, fine- to medium-grained; very calcareous; much vein material and iron staining; fracture zone; water course—20 gpm at 109 ft	9	108–117
Sandstone, green-gray, medium-grained; very micaceous (fine grained); much black fibrous coating on fracture surfaces; thin bedded; fissile	8	117–125
Sandstone, medium-gray, medium-grained, massive; micaceous, larger grained near bottom; hard	15	125–140

Table 18. (*Continued*)

Description	Thickness (feet)	Depth (feet)
Siltstone, medium- to dark-gray, sandy; very fissile with distinct bedding and crossbedding; shale partings; little mica	5	140–145
Sandstone, medium-gray grading to light-gray, medium-grained grading to coarse-grained; silty and shaly, very fissile, thin bedded; manganese coating on grains; finely disseminated mica; small amount of fine-grained pyrite and opaque white vein material at bottom	10	145–155
Sandstone, light-gray, medium-grained; massive; very little lime and little mica; black mineral grains; finely disseminated pyrite at bottom	20	155–175
Sandstone, light- to medium-gray, fine- to medium-grained; some fissility; much dark mineral and iron staining	5	175–180
Sandstone, light-gray, fine- to medium-grained; massive with some fissility near bottom; pink transluscent quartz veins; very hard; some crystals of black mineral and iron staining	20	180–200
Sandstone, medium- to dark-gray, fine-grained; chloritic and micaceous; very friable; contains bedded coal	20	200–220
Sandstone, light-gray, medium-grained; very hard, massive; little mica, slightly limy	15	220–235
Siltstone, reddish-brown; medium-grained sand; very hard, very calcareous; some vein material; water level—58 ft below land surface datum	2	235–237
Sandstone, reddish-brown, fine-grained, grading to very fine grained near bottom; a few fracture or bedding surfaces with silt or shale and large reddish mica flakes; slightly pyritic and slightly calcareous; interbedded red shales at bottom; fracture zone; water course—5 gpm at 258 ft	21	237–258
Shale, red, silty; finely laminated and fissile; slightly limy	2	258–260
Siltstone, red, very fine grained sand; red clay and calcite vein material; limonite stain; large red mica flakes and clear white disseminated mica; possible fracture zone	5	260–265
Siltstone, red, shaly; finely laminated; some dark-gray, coarse-grained sand grains; shales show signs of squeezing and distortion; microfolding or drag folding present	5	265–270
Shale, red, silty; highly distorted; finely laminated and hard; breaks across bedding planes; interbedded dark-gray to black siltstone near bottom, containing possible plant remains; fracture zone with clay gouge and slickensides	5	270–275
Sandstone, red, very fine grained, silty, hard; slightly fissile with much finely disseminated white mica; much fracturing with iron stains; calcareous; water course—approximately 2 gpm	5	275–280
Shale, red, silty, very friable and broken; interbedded brown to gray sandstone ledge material; much black and yellow staining; very micaceous between silt and sandstone beds; chloritic with white clay gouge material; water course—100 gpm at 283 ft; water level rose to 52 ft below land surface datum; upper water-bearing zones grouted off to 120 ft	5	280–285

Table 18. (*Continued*)

Well Lk-318

Owner: Pocono Joint School District
Altitude: 1,700
Driller: Tully Drilling Co., Inc.
Drilled: 1967
Static water level: 42 ft
Reported yield: 39 gpm

Description	Thickness (feet)	Depth (feet)
Soil, light-brown, clay and very fine sand	10	0– 10
Glacial till, light brown, clay and some very fine sand	60	10– 70
Glacial till, brown, some fine sand and coarse sand	10	70– 80
Sandstone, reddish-gray, fine-grained, angular; silty	20	80–100
Siltstone, reddish-gray; sandy, very fine grained; soft	20	100–120
Siltstone, light-brown, shaly; weathered zone	20	120–140
Shale, reddish-brown	15	140–155
Siltstone, reddish-brown	5	155–160
Siltstone, gray; sandy, very fine grained	10	160–170
Sandstone, gray, very fine grained	15	170–185
Shale, gray	5	185–190
Shale, reddish-brown; silty	10	190–200
Sandstone, gray, very fine to fine-grained; water zone at 210 ft below land surface datum	30	200–230
Shale, reddish-brown to gray; silty	10	230–240
Sandstone, gray-green; very fine grained; silty	15	240–255
Sandstone, gray-green, fine- to medium-grained; conglomeratic	5	255–260
Sandstone, gray-green, medium- to coarse-grained; shaly, reddish brown	15	260–275
Siltstone, reddish-brown; shaly	20	275–295
Sandstone, gray-green, very fine to fine-grained; silty	15	295–310
Siltstone, reddish-brown; shaly	20	310–330
Siltstone, reddish-brown; sandy, fine grained	15	330–345
Sandstone, gray-green, very fine to fine-grained; grades to very fine grained sandstone near bottom	55	345–400

Well Lk-388

Owner: Edwards Bros. Meat Packing Co. Well #3
Altitude: 1280
Driller: Tully Drilling Co., Inc.
Drilled: 1970
Static water level: 151 ft
Reported yield: 223 gpm

Description	Thickness (feet)	Depth (feet)
Boulder gravel, sand, silt (glacial till), soil zones with low-grade bog ore near bedrock and in crevices	20	0– 20
Sandstone, light-gray to white, fine-grained, limonitic; some rounded pebbles and rock fragments; slightly calcareous and fissile	4	20– 24

Table 18. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Siltstone, light-brown to dark-red and variegated; iron stain on fragments, slightly calcareous, and very friable and fissile	4	24– 28
Sandstone, light-brown to medium-gray, fine- to medium-grained; silty; abundant, very coarse mica (white); very friable with indistinct bedding planes of brown mica; very calcareous and moderately carbonaceous; fracture zone at 30 ft	7	28– 35
Siltstone, light-brown to medium-gray, shaly; slightly calcareous and carbonaceous; highly fractured with much iron staining; some finely disseminated mica; moderately fissile; white clay mineral; fault gouge and slickensides indicated	5	35– 40
Sandstone, light-brown to dark-gray, fine-grained; much vein material, friable; hard, very calcareous; vein calcite, chloritic and fissile	4	40– 44
Siltstone and shale, medium-gray to green; some fissility but much like a mudstone with indistinct bedding planes; little lime; massive pyrite in fractures, iron stain and mica (pyrite not abundant)	3	44– 47
Sandstone, light-gray to brown, fine- to medium-grained, silty at 60 ft; hard to very hard; little mica near top, large brown crystals in center and finely disseminated near bottom; slightly limy; vein material of clay in fracture zone with finely disseminated pyrite; coal fragments and black and resinous minerals; massive rock predominates; water course—1 gpm at 60 ft	16	47– 63
Sandstone, medium-brown, medium- to coarse-grained; silty and shaly; black and white vein material in fractures; slightly limy, iron stain, and some mica; large fracture zone with voids at 70 to 71 ft	8	63– 71
Siltstone, light-brownish gray, shaly; ledge rock (flaggy sandstone) at 76 ft; inclusions of mudstone, disseminated pyrite and only minor mica and carbonaceous material; water course—1 gpm at 76 ft; highly fractured	6	71– 77
Sandstone, medium- to dark-gray, medium- to coarse-grained; very carbonaceous with abundant coal fragments and moderately limy; slickensides with black stain and extremely friable clay mineral; slightly fissile with indistinct bedding planes; water course	4	77– 81
Siltstone, medium- to dark-gray; shaly and interbedded sandstone; carbonaceous material; very slightly micaceous, hard and somewhat massive	10	81– 91
Shale, gray-green; carbonaceous, micaceous, calcareous; friable	4	91– 95
Siltstone, red, sandy, very calcareous	2	95– 97
Shale, gray, silty; very fissile, friable; calcareous and micaceous; iron stain, oxidizing zone	9	97–106
Sandstone, light- to dark-gray, grading from fine-grained to medium-grained and back to fine- and medium-grained at the bottom (cyclic); distinct bedding planes, extremely fissile; seamy-glauconitic to very carbonaceous near bottom; very calcareous; interbedded silt and shale partings near bottom; hard grading to soft; large mica flakes grading to finely disseminated; iron stains in fractures; shale, green; highly fractured; water course—25 gpm at 144 ft, water level—86 ft below land surface datum	39	106–145

Table 18. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Sandstone, grayish-green-red, fine- to medium-grained; distinct bedding planes, large mica grains; seamy at 146 ft; slightly calcareous, iron staining; water course; highly fractured zone	2	145–147
Siltstone, red and variegated green; shaly; iron stain, highly fissile; black carbonaceous material (coal?); little lime	6	147–153
Sandstone, medium-gray, fine-grained, hard; some shale partings with bedding planes	3	153–156
Siltstone, red and variegated gray-green; vein calcite, fissile, micaceous; slickensides; fracture zone	9	156–165
Sandstone, greenish-gray grading to dark-gray, silty and fine-grained grading to medium-grained near bottom; little pyrite, micaceous; black, seamy iron stain with calcite and mica crystals; some fractures	18	165–183
Siltstone, light-grayish-green; sandy, fine-grained; very friable; chloritic and micaceous; very calcareous	4	183–187
Siltstone, red; sandy (fine grained); calcite vein material; iron stain in fractures; finely disseminated mica (rhombs), friable	7	187–194
Siltstone, light-gray-green, very micaceous; contains very fine grained and very calcareous sand; friable, distinct bedding planes	4	194–198
Sandstone, medium-gray-green grading to medium- to dark-gray; fine grained grading to medium and coarse grained near the bottom; silty, very calcareous; hard near top, more friable near bottom; pyritic and calcite veins at 210 ft; plant fragment near bottom replaced by pyrite and coal; water course with iron stain at 213 ft	34	198–232
Siltstone, black, shaly, very limy	2	232–234
Sandstone, medium-gray, medium-grained, very hard, some mica, very limy	5	234–239
Shale, red, silty, very finely micaceous; noncalcareous, distinct bedding planes; iron stain	12	239–251
Sandstone, medium-gray, fine- to medium-grained; silty, very calcareous; large mica flakes (copper colored); very friable and fissile; seamy (calcite) and carbonaceous lenses of coal; water course—25 gpm at 251 ft	17	251–268
Sandstone, light-gray, medium-grained, massive, hard, slightly pyritic, calcareous	4	268–272
Sandstone, medium-gray, fine-grained, fissile, silty, small amount of mica, very calcareous	2	272–274
Sandstone, light- to medium-gray, fine- to medium-grained; massive; very hard, small amount of mica, slightly calcareous; coal fragments and seamy at 288 ft	56	274–330
Sandstone, medium- to dark-gray, fine- to medium-grained; fissile with indistinct bedding planes; silty, finely micaceous; carbonaceous and limy	36	330–366
Sandstone, light- to medium-gray, fine- to medium-grained; slightly pyritic, very seamy with many calcite veins; large mica flakes; carbonaceous and very calcareous; water course—25 gpm at 369 ft	12	366–378

Table 18. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Sandstone, medium-gray, coarse-grained, conglomeratic with interbedded silt and lime; much light yellow dolomitic vein material; finely disseminated pyrite; large mica flakes and coal fragments; appearance of calcarenite; water course—100 gpm	2	378–380
Siltstone, dark-gray; very sandy, light-gray grading to dark-gray and black; coarse grained grading to very fine grained; interbedded carbonaceous material; iron stains and pyritic near top, and very limy grading to no lime; may be dolomitic in part; fracture zone; water level—132 ft below land surface datum	24	380–404
Siltstone, dark-gray to black, very shaly, very fissile; massive pyrite (minor); some vein material; micaceous (very fine), no lime; considerable crossbedding	16	404–420
Sandstone, light- to medium-gray, fine- to medium-grained; conglomeratic, seamy, very calcareous and limonitic; carbonaceous and traces of pyrite; coal fragments; water course—45 gpm at 437 ft	17	420–437
Siltstone, medium-gray; fine-grained sand; friable; much coal and pyrite, seamy with calcite fragments from interbedded calcite and shale lenses; water course	8	437–445
Sandstone, medium- to dark-gray, medium-grained (uniform grain size); interbedded black siltstone and shale, very limy, pyritic; little mica, iron stains; increased shale partings near bottom; some minor fracture zones	25	445–470
Sandstone, light- to medium-gray, medium-grained; very hard; trace of pyrite and mica (larger flakes near bottom); large amount of dark mineral; iron stain and moderate amount of lime; water level dropped to 151 ft below land surface datum	30	470–500

Table 19. *Public and Institutional Water Supplies in Lackawanna County*

Supplier	Area served	Population	Number of services	Delivery, in thousands of gallons per year	Source and treatment	Ownership	Sewage disposal
Pennsylvania Gas and Water Company	Scranton Archbald Blakely Carbondale[1] Clinton[3] Dickson City Dunmore[2] Fell Forest City[3] Jermyn Mayfield Moosic Old Forge Olyphant Scott South Abington Township Taylor Throop Vandling Winton	140,000	46,000	31,739,566	Wells Lk-7, 15, 406, and 407. Artificial impoundment of 12 streams and numerous springs; alum and lime; sand filters and activated carbon; chlorine and ammonia with alkali for pH adjustment.	Public utility	Primary treatment; sludge removal and disinfection (chlorine only).
American Water Works Service Company	Clarks Summit South Abington Abington Township Dalton Borough Clarks Green	7,000	2,368	247,000	Wells Lk-92, 222, 251, 252, 258, and 394. Artificial impoundment; chlorination.	Public utility	Primary treatment; sludge removal and disinfection (chlorine only).
Abington Township	Waverly North Abington Township	480	150	12,000	Wells Lk-230 and 238, one standby. Chlorination.	Municipal	Primary treatment; sludge removal and individual septic tanks. Two new secondary treatment plants complete — not operated.

Stanton Water Company	South Abington Township	140	40	6,500	Well Lk-408. Chlorination.	Private	Individual septic tanks.
Hall Water Supply Company	Chinchilla	273	78	7,707	Well Lk-409 and spring. Chlorination.	Private	Individual septic tanks.
Marshall Water Supply Company (Lomma Enterprises)	Chinchilla	266	76	2,977	Well Lk-410. Chlorination.	Private	Individual septic tanks.
Sunset Hills Water Company (Lomma Enterprises)	North Abington Township Waverly	74	21	1,553	Well Lk-411. Chlorination.	Public utility	Individual and community septic tanks.
Glenburn Community Water Supply	Glenburn	250	50	2,920	Well Lk-188. Chlorination.	Public utility	Individual and community septic tanks.
Park Terrace Water Company (Lomma Enterprises)	Glenburn	200	42	2,000	Well Lk-242. Chlorination.	Public utility	Individual and community septic tanks.
Factoryville Water Company (Lomma Enterprises)	Factoryville[3] Dalton LaPlume	980	300	11,680	Wells Wy-63 and 65 and lake. Chlorination.	Public utility	Individual septic tanks.
Clarks Summit State Hospital	Clarks Summit State Hospital	1,100 patients 507 employees	—	80,300	Wells Lk-286, 287, and 288. Chlorination.	State	Secondary; aeration, sludge removal, disinfection.
Lackawanna County Home	Lackawanna County Home	230 patients 130 employees	—	16,425	Gardner Creek, well Lk-9 (standby). Storage, filtration, and chlorination.	County	Better than primary; filtration and sludge removal; disinfection.
West Mountain Sanitorium	West Mountain Sanitorium	54 patients 60 employees	—	5,110	Spring Sp-2 and wells Lk-111 and 112. Settling and chlorination.	County	Secondary; comminution; aeration; disinfection.
Blakely Convalescent Home	Blakely Convalescent Home	132 patients 70 employees	—	6,935	Two wells.[4] Chlorination.	County	Primary, sludge removal; disinfection.
Hamlin Water Service	Dunmore	105	30	2,203	Artificial impoundment, filtration and chlorination.	Private	Less than primary; disinfection.
Moscow Water Company (Lomma Enterprises)	Moscow Borough	810	260	21,000	Artificial impoundment from 12 springs (3 acres). Calgon and chlorination.	Public utility	Individual septic tanks.

Table 19. *(Continued)*

Supplier	Area served	Population	Number of services	Delivery, in thousands of gallons per year	Source and treatment	Ownership	Sewage disposal
Moscow Development Association	Moscow Borough	120	30	3,285	One well.[4] Chlorination.	Private	Individual septic tanks.
Gardner Development	Moscow Borough	75	25	2,000	One well.[4] Filtration and chlorination.	Private	Individual septic tanks.
Independent Water Company	Moscow Borough	35	11	960	Spring. Chlorination.	Private	Individual septic tanks.
Olwen Heights Water Company	Roaring Brook Township	475	128	8,873	Well Lk-322, 323, and 324. Chlorination.	Private	Individual and community septic tanks.
Elmbrook Terrace Water Company (Lomma Enterprises)	Roaring Brook Township	180	50	4,500	Well Lk-325. Chlorination.	Public utility	Secondary; comminution; aeration and filtration; sludge removal; disinfection.
Poco Springs Water Company (subsidiary of Pennsylvania Power and Light Company)	Roaring Brook Township	190	54	4,930	Wells Lk-99, 320, and 321. Chlorination.	Public utility	Secondary; comminution; aeration and filtration; sludge removal; disinfection.

[1] Reynshanhurst reservoir supplied by deep well (Lk-7).
[2] Dunmore reservoir supplemented during drought by Nay Aug wells (Lk-406 and 407).
[3] Outside county.
[4] Not inventoried.

Table 20. *Chemical Analyses of Water from Wells and Springs in Lackawanna and Adjoining Counties*

(Analyses by U.S. Geological Survey in milligrams per liter, except as indicated)

Well number	Date of collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Total iron (Fe)	Total manganese (Mn)	Copper (Cu)	Zinc (Zn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hydrogen sulfide (H_2S)	Sum of dissolved constituents	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH: Laboratory	pH: Field	Remarks
Lk- 7	12-13-68	9.2	5.2	—	0.01	0.00	0.00	—	9.0	1.9	2.4	0.4	34	5.7	1.5	—	0.3	—	44	30	2	72	—	6.8	—
15	12-13-68	9.4	—	—	.02	.00	—	—	16	2.8	6.2	.6	—	—	—	—	—	—	85[a]	52	—	130	—	7.1	—
53	11-21-68	12.0	—	—	.02	.14	—	0.13	43	4.8	8.7	—	146	15	4.9	—	5.7	odor	164	127	8	277	—	7.4	—
89	2-23-70	8.0	—	—	—	—	—	—	—	—	—	—	134	—	131	—	—	—	—	183	73	763	7.9	—	32 ft, yield 1 gpm
89	2-23-70	8.4	—	—	—	—	—	—	—	—	—	—	136	—	127	—	—	—	—	170	58	792	7.9	—	57 ft, 3 gpm
89	2-24-70	8.4	—	—	—	—	—	—	—	—	—	—	114	—	118	—	—	—	—	209	116	675	7.3	—	60 ft, 4 gpm
89	2-24-70	8.7	—	—	—	—	—	—	—	—	—	—	108	—	104	—	—	—	—	202	114	656	7.8	—	78 ft, 30 gpm
89	2-24-70	9.0	—	—	—	—	—	—	—	—	—	—	142	—	82	—	—	—	—	197	88	609	7.6	—	188 ft, 60 gpm
89	2-25-70	9.2	—	—	—	—	—	—	69	6.6	31	5.8	110	52	87	—	9.2	—	325	199	109	563	7.7	—	260 ft, 80 gpm
89	2-25-70	9.2	—	—	—	—	—	—	—	—	—	—	108	—	83	—	—	odor	—	187	98	559	7.9	—	300 ft, 100 gpm
89	6-17-70	9.4	—	0.1	.01	.00	—	.00	74	6.5	—	—	—	15	—	—	—	—	251	211	122	518	—	7.7	After pumping 3 hrs. at 25 gpm
99	8- 4-70	11.3	—	—	1.2	.03	—	—	28	2.8	—	—	78	9.8	2.5	0.2	1.1	—	—	82	18	159	7.2	7.2	108 ft, 20 gpm
99	8- 5-70	9.3	—	—	—	.03	—	—	28	3.4	—	—	99	6.5	3.1	.2	1.4	—	—	84	3	189	7.9	7.9	258 ft, 30 gpm
99	8- 5-70	10.2	—	.0	.07	.01	—	.00	35	4.2	2.3	—	108	11	2.8	.2	1.3	—	117	106	17	205	7.7	7.0	283 ft, 120 gpm
99	9-29-70	—	—	—	.07	.05	—	.00	32	8.5	2.0	—	109	—	—	—	—	—	—	110	21	262	—	—	Before pumping test
99	9-30-70	—	7.7	.0	.01	.01	—	.00	34	3.8	3.3	1.0	108	6.7	5.0	.0	1.0	—	116	101	12	205	7.6	—	At 24 hrs. of pumping
108	12-12-68	11.2	8.0	—	.07	.01	.13	—	36	5.1	3.6	1.1	59	51	6.7	—	12	—	153	111	62	283	—	6.6	Nickel-0.00
109	12-12-68	8.6	4.1	—	0.00	0.02	0.00	—	5.7	1.2	1.2	0.7	7	13	0.3	—	3.2	—	33	19	14	54	—	5.7	Nickel-0.00
110	1- 2-69	11.7	—	—	9.9	—	—	—	—	—	1.0	—	31	13	2.4	—	.0	—	38[a]	25	0	58	—	6.2	—
111	1- 2-69	8.2	—	—	7.7	—	—	—	—	—	1.2	—	79	12	2.0	—	.2	—	89[a]	64	0	137	—	6.8	—
112	1- 2-69	9.9	—	—	4.5	—	—	—	—	—	1.0	—	46	14	1.0	—	.2	—	65[a]	44	6	100	—	6.3	—
114	9-24-69	9.0	—	.5	2.2	.25	.00	5.5	13	4.3	—	—	—	—	—	—	—	—	76[a]	50	—	117	—	6.7	—
115	9-18-69	11.0	—	—	.02	.00	—	—	54	8.1	—	—	111	—	41	—	—	—	270[a]	168	77	415	—	7.4	
117	9-18-69	11.0	—	—	.06	1.2	.00	—	34	6.6	—	—	140	—	3.6	—	—	—	162[a]	112	0	250	8.1	—	—
118	9-30-69	10.0	—	1.5	2.6	.10	.00	.00	—	—	—	—	—	—	—	—	—	—	114[a]	68	—	175	—	7.7	—
121	11- 7-68	10.5	8.3	—	.17	.04	—	—	36	4.4	13	1.2	158	6.7	1.6	—	.3	—	150	108	0	259	—	7.7	—
122	11-22-68	8.9	—	—	11	1.5	.31	.11	5.3	4.3	.4	—	53	7.7	1.0	—	1.6	—	64	30	0	86	—	6.5	Nickel-0.00
123	12-12-68	10.6	8.0	—	.00	.00	.05	—	33	4.2	11	1.0	134	8.5	2.3	—	4.6	—	139	100	0	249	7.7	—	Nickel-0.00

Table 20. *(Continued)*

Well number	Date of collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Total iron (Fe)	Total manganese (Mn)	Copper (Cu)	Zinc (Zn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hydrogen sulfide (H_2S)	Sum of dissolved constituents	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH: Laboratory	pH: Field	Remarks
124	12-12-68	10.4	8.2	—	.03	.00	.00	—	41	9.9	11	1.0	198	5.0	0	—	1.4	—	176	143	0	316	—	7.5	Nickel-0.00
125	1-14-69	10.3	—	—	04	—	—	—	—	—	6.0	—	95	21	13	—	1.9		162[a]	107	29	249	—	7.1	—
130	1-16-69	11.2	—	—	.17	—	—	—		—	13	—	60	37	17		4.2	—	149[a]	87	38	229	—	6.3	
142	7-10-69	11.0	—	—	.53	03		—	30	1.7	12		93	27	1.3	—	2.9	—	132	82	6	215	7.7	7.5	—
150	11-8-68	11.0	—	—	72	.01	—	—	11	1.2	95	3.6	39[b]	—	—	—	—	odor	—	32	1	625	9.5		—
150	11-14-68	11.0	7	—	24	01	.18	3.8	12	1.3	103	3.7	25[b]	1.0	179	.1	1	<1.5	325	36	4	671	9.5	9.4	Nickel-0.00, lead-0.00
177	11-4-68	12.0	—	—	0.37	0.00	—	—	28	3.8	5.2		98	11	3.0	—	1.8	—	110	86	5	201	—	7.5	—
179	10-16-68	12.0	10	0.1	1.3	26		—	30	3.7	9.0	1.1	139	3.9	2.0	0.3	1	odor	130	90	0	219	8.1		
190	10-30-68	12.0	—	—	02	04	—	—	35	4.8	22		179	3.9	2.7		4		167	107	0	304	—	7.8	
194	10-30-68	12.0	—	—	.00	00	—	—	35	1.4	7.4	—	132	8.2	2.5	—	2.0		134	106	0	251	—	7.7	
204	7-11-69	12.0	—	—	.00	00	—	—	49	6.2		—	91	—	40		—	—	231[a]	148	74	355	—	7.7	
206	6-25-69	11.0	—	—	03	01	—	—	33	6.0	—		126		3.6			—	169[a]	107	4	260	—	7.9	
211	10-30-68	13.0	—	—	01	01	—	—	40	5.1	11	—	166	7.7	1.1		7		157	121	0	278	—	7.7	—
213	10-15-68	12.3	9.3	—	.02	—	—	—	44	4.5	8.7	—	150	13	3.0	3	8.9		166	128	6	289		7.7	—
215	10-17-68	11.7	8.6	—	.03	—	—	—	39	5.6	9.2	—	164	3.9	0	3	1.4	—	149	120	0	268		7.6	—
216	10-17-68	13.0	9.6	—	.02	—	—	—	42	4.3	9.1	—	128	11	14	2	7.3	—	161	122	18	294	—	7.4	—
217	1-2-69	10.0	—	—	15	—	—	—	—	—	7.8	—	73	17	6.4	—	2.0		113[a]	74	14	174	—	6.5	—
218	11-22-68	7.3	—	—	17	.17	—	.03	35	2.9	18	—	150	9.1	4.5	—	1.0	2.5	153	100	0	246	7.9	—	—
222	2-3-69	8.7	9.2	.0	80	.04	.00	05	12	3.0	57	6.0	161	6.9	32	—	2	3.5	206	42	0	355	8.1	7.4	Flowing at 60 gpm
222	2-11-69	10.2	—	—	1.1	.05	—	—	10	1.6	—	—	168	—	126		—	2.0	—	32	0	645	8.2	7.8	After 2 hrs. pumping at 100 gpm
222	2-11-69	10.4	8.9	0	.70	.04	.01	.02	15	1.5	130	6.7	168	3.2	132	2	4	1.5	382	44	0	670	8.2	7.9	After 10 hrs. pumping at 125 gpm
224	2-4-69	8.7	—	—	50	—	—	—	—	—	6.2	—	75	24	3.2	—	1.5	—	116[a]	78	16	179	—	6.8	—
230	3-25-69	10.4	—	—	1.1	—	—	—	—	—	23	—	172	7.7	5.8		0	5.0	202	104	0	310	—	7.5	—
232	9-10-70	9.7	9.5	0.0	0.09	0.06	0.00	0.02	41	6.0	29	—	152	32	21	0.1	8.0	odor	222	127	3	398	7.8	7.7	Pumped 3 hrs. from 80 ft
232	9-10-70	10.2	—	—	.50	.28	—	—	41	6.0	36	—	154	25	31	—	11	.5	237	127	1	448	7.8	—	Sampled at 360 ft
232	9-10-70	10.7	9.2	.0	.60	.26	.00	.04	36	5.0	83	—	160	26	89	2	9.8	1.8	340	111	0	535	7.6	—	Sampled at 440 ft
233	7-29-69	10.1	—	—	.57	—	—	—	—	—	—	—	—	—	7.7	—	—	3.0	—	117	—	325	7.9	—	—
235[c]	4-22-69	9.9	—	—	.18	.00	—	—	—	—	—	—	146	10	140	—	3.9	odor	340	92	0	480	7.7	—	—
238	3-25-69	10.7	—	—	.05	.00	—	—	39	5.0	8.7	—	133	15	7.2	—	3.4	—	153	118	9	270	—	7.1	—

240[d]	2- 9-66	—	—	—	.01	.00	—	—	17	2.3	—	—	44	—	3.0	—	—	—	79[g]	52	16	105[a]	6.3	—	Before pump test
240[d]	2-11-66	—	—	—	.04	.00	—	—	16	3.9	—	—	48	—	4.0	—	—	—	84[g]	56	16	112[a]	6.4	—	After 46 hrs. pumping
241[d]	2- 7-66	—	—	—	.08	.15	—	—	53	14	—	—	141	—	570	—	—	—	1,150[g]	190	74	1,600[a]	7.9	—	Before pump test
241[d]	2- 9-66	—	—	—	.23	.20	—	—	54	14	—	—	134	—	602	—	—	—	1,210[g]	192	82	1,680[a]	7.9	—	After 46 hrs. pumping
244	10- 8-62	11.2	—	—	—	—	—	—	—	—	—	—	96	13	1,900	—	8.8	—	3,700[a]	264	186	6,100	8.0	—	Lithium–4.5; gaseous
244	1- 8-69	11.4	—	—	3.4	—	—	—	—	—	7.8	—	110	11	15	—	3.7	odor	141[a]	102	12	257	7.9	—	Gaseous
245	11-19-68	11.5	—	—	.00	.00	—	.34	38	4.1	19	—	173	4.8	4.1	—	1.2	odor	166	112	0	308	—	7.7	Salt water when drilled
248	2- 5-69	10.0	—	—	.03	—	—	—	—	—	6.4	—	98	12	1.6	—	5.1	—	122[a]	85	4	188	—	7.4	—
251[e]	12-19-68	—	—	—	.00	.00	—	—	12	2.4	31	—	90	9.0	12	—	8.0	—	126[g]	40	0	200[a]	7.5	—	—
251[e]	8-13-69	11.0	—	—	.43	.00	—	—	28	4.9	14	—	113	9.0	9.0	—	8.2	odor	140	90	0	250	8.1	7.7	H_2S and salt; plugged back
252[e]	12-27-68	—	—	—	.10	.00	—	—	17	10	29	—	132	5.5	20	—	8.4	—	182[g]	84	0	305[a]	7.5	—	—
Lk-253[e]	9-26-69	11.0	—	0.3	0.58	0.08	0.06	0.03	15	2.8	—	—	—	—	—	—	—	—	77[a]	49	—	118	—	7.3	—
254	11- 7-69	11.1	—	.2	.17	.00	.00	.02	—	—	—	—	133	—	19	—	—	—	200[a]	138	29	308	8.0	—	—
267	11- 7-69	9.9	—	.2	.41	.19	.00	.00	—	—	—	—	238	—	.6	—	—	—	292[a]	115	0	449	7.9	—	—
269	10-23-69	9.5	—	.0	.00	.00	.00	.01	—	—	—	—	183	—	20	—	—	odor	229[a]	42	0	352	7.9	—	—
272	10-10-69	11.1	—	.0	.06	.38	.00	.01	—	—	—	—	126	—	22	—	—	—	172[a]	108	4	265	7.9	—	—
281	11-13-69	9.4	—	.1	.13	.08	.00	.02	—	—	—	—	219	—	1.8	—	—	—	227[a]	134	0	349	7.8	—	—
320	4-22-70	9.3	7.8	—	7.9	.50	.02	.05	36	3.9	2.3	.6	103	13	7.1	—	3.8	—	134	106	22	216	8.2	—	Nickel–0.03; phosphate–0.60
321[f]	2- 4-70	—	—	—	.03	.00	—	—	—	—	—	—	95	—	9.0	.0	.0	—	80[g]	74	0	123	7.3	—	Phosphate–0.85
341	9-25-69	10.0	—	.4	.50	.25	.00	.04	12	3.9	—	—	—	—	—	—	—	—	67[a]	46	—	103	—	7.4	—
342	10- 2-69	9.2	—	.2	.28	.02	.00	.00	—	—	—	—	—	—	—	—	—	—	44[a]	34	—	68	—	7.3	—
366	10-22-69	9.0	—	.2	.38	.02	.00	.01	—	—	—	—	34	—	1.6	—	—	—	59[a]	38	10	91	—	7.5	—
378	4- 7-70	—	—	—	.10	—	—	—	38	4.2	—	—	112	—	30	—	1.3	odor	207[a]	113	21	319	—	7.2	Organics
386[h]	3-18-70	10.7	—	—	.05	—	—	—	59	3.4	—	—	206	24	5.0	—	.2	—	185[g]	162	0	340	7.4	—	—
387[h]	4-15-70	10.2	—	—	.08	—	—	—	44	2.4	—	—	224	35	8.0	—	.4	—	202[g]	119	0	353	7.3	—	—
388	4-15-70	11.2	8.9	—	.09	—	—	—	43	8.0	14	1.4	196	10	1.1	.1	1.9	—	185	141	0	330	7.9	7.2	146 feet, 25 gpm
388	4-22-70	10.2	12	—	—	—	—	—	34	4.7	15	2.9	159	8.9	5.7	.1	.2	—	163	105	0	286	8.0	—	379 feet, 230 gpm
388	5- 1-70	10.2	11	—	.14	.09	—	—	38	4.5	16	2.6	173	9.2	6.3	.2	.9	—	174	114	0	304	8.2	7.4	Phosphate–0.01. End 24 hr. pumping test.
397	10-22-69	9.3	—	0.6	2.8	0.07	0.00	0.01	—	—	—	—	75	—	0.4	—	—	—	82[a]	61	0	126	7.9	—	—
403	8-18-70	13.1	12	2.5	29	2.4	.03	3.0	20	7.0	3.0	—	25[j]	132	1.0	.0	1.1	—	225	79	58	295	3.40	5.62	Ferrous iron–12
404	9-11-70	10.0	11	.0	.07	.06	.00	.01	26	4.3	58	—	216	11	14	.2	.0	odor	231	83	0	396	8.0	—	—
406	6- 4-71	10.5	7.2	—	.04	.02	—	—	23	4.1	16	1.3	108	14	5.2	.2	.0	—	124	75	0	214	7.7	—	—
407	6- 4-71	10.0	6.6	—	.04	.01	—	—	22	3.4	26	1.1	106	14	17	.1	.2	odor	143	69	0	258	7.8	—	—
Sq- 60	1-14-69	9.3	—	—	.16	—	—	—	—	—	19	—	189	2.9	1.2	—	.5	—	196[a]	119	0	301	—	7.7	—
Wy- 64	3-26-69	7.8	—	—	.20	—	—	—	—	—	22	—	132	2.4	11	—	.1	—	164[a]	77	0	253	—	7.7	—
65	3-17-70	10.1	—	.0	.13	.06	.00	.00	—	—	—	—	—	—	—	—	—	odor	181[a]	94	—	278	—	7.7	—
66	8-19-70	13.1	8.3	.0	.05	.09	.00	.02	10	2.0	205	5.0	222	1.2	230	.8	.4	—	572	33	0	980	8.3	8.3	Lithium–0.68. Flowing

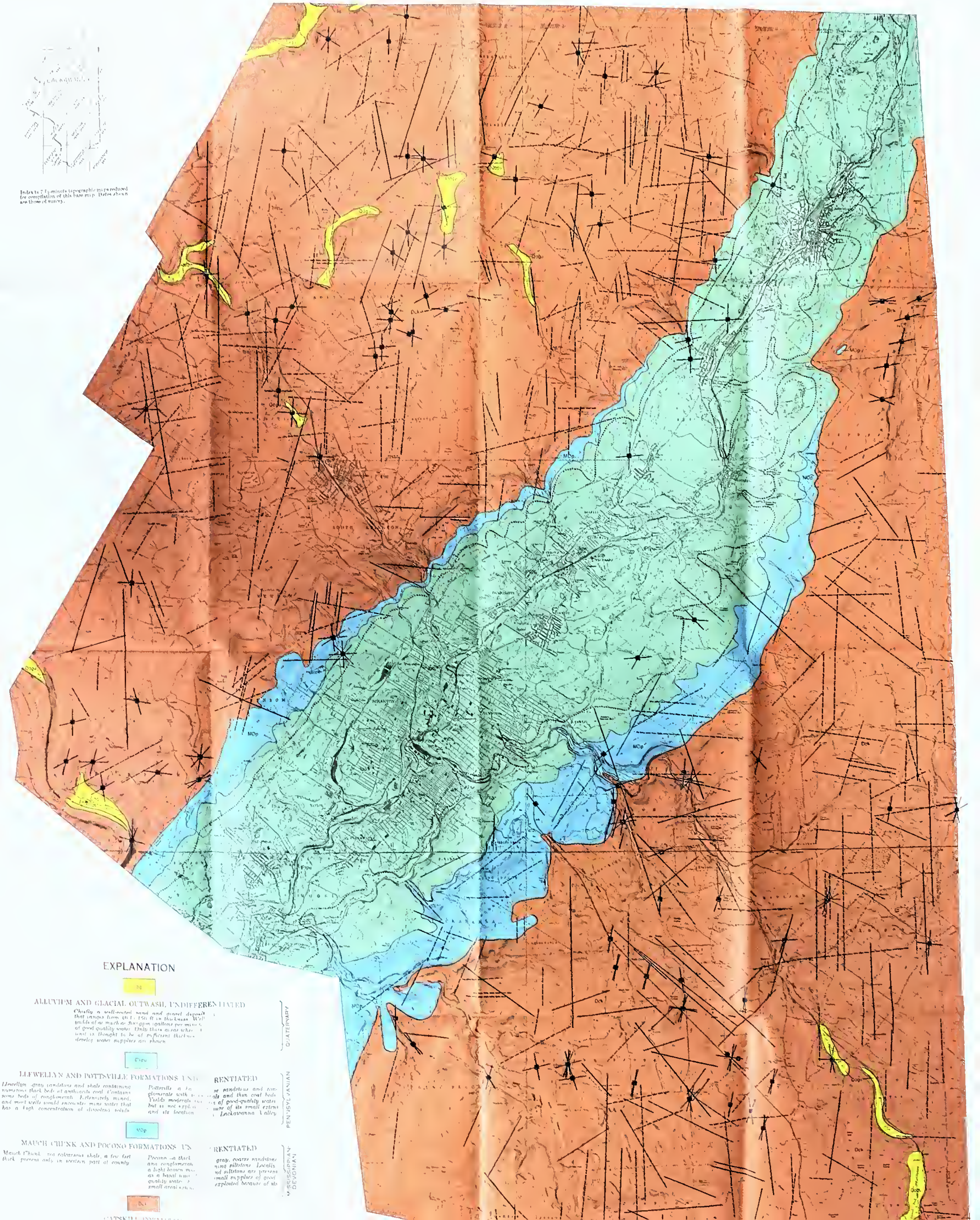
Table 20. *(Continued)*

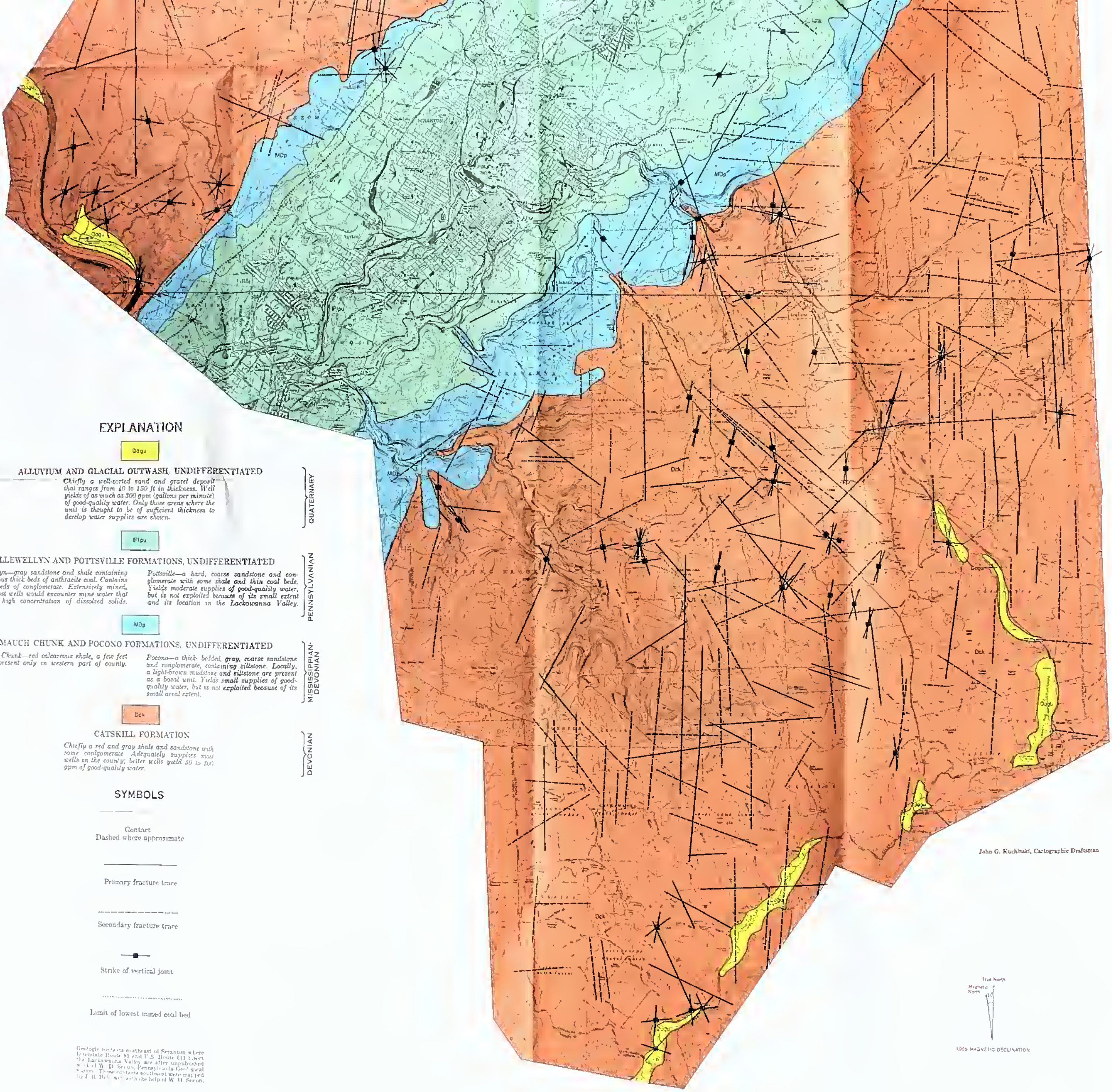
Well number	Date of collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Total iron (Fe)	Total manganese (Mn)	Copper (Cu)	Zinc (Zn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hydrogen sulfide (H_2S)	Sum of dissolved constituents	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH		Remarks
																				Calcium, magnesium	Noncarbonate		Laboratory	Field	
Springs																									
Lk-Sp-1	12-12-68	10.0	4.6	—	.02	.00	.00	—	5.8	2.3	1.0	.8	16	11	.9	—	1.0	—	44	24	11	65	—	5.9	Nickel-.000
Sp-2	1- 2-69	5.5	—	—	.08	—	—	—	—	—	1.0	—	8	7.7	.2	—	.0	—	25[a]	13	6	38	—	5.9	—
Sp-3	3- 5-70	—	—	—	2.2	.50	—	—	—	—	—	—	—	—	—	—	—	—	29[a]	—	—	45	—	6.2	—

[a] Estimated.
[b] Includes carbonate.
[c] Analysis by Pennsylvania Department of Health.
[d] Analysis by Both, Garrett and Blair, Inc., Philadelphia, Pa.
[e] Analysis by Gwin Engineers, Inc., Altoona, Pa.
[f] Analysis by Wm. J. Breese, Scranton, Pa.
[g] Total solids (residue on evaporation).
[h] Analysis by Costello's Laboratory, Inc., Binghamton, N. Y.
[j] Field determination.
[k] Depth of well at time of collection.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

W 41, Plate 1





EXPLANATION

Qagu

ALLUVIUM AND GLACIAL OUTWASH, UNDIFFERENTIATED

Chiefly a well-sorted sand and gravel deposit that ranges from 40 to 150 ft in thickness. Well yields of as much as 300 gpm (gallons per minute) of good-quality water. Only those areas where the unit is thought to be of sufficient thickness to develop water supplies are shown.

QUATERNARY

IPlpu

LLEWELLYN AND POTTSVILLE FORMATIONS, UNDIFFERENTIATED

Llewellyn—gray sandstone and shale containing numerous thick beds of anthracite coal. Contains some beds of conglomerate. Extensively mined, and most wells would encounter mine water that has a high concentration of dissolved solids.

Pottsville—a hard, coarse sandstone and conglomerate with some shale and thin coal beds. Yields moderate supplies of good-quality water, but is not exploited because of its small extent and its location in the Lackawanna Valley.

PENNSYLVANIAN

MDp

MAUCH CHUNK AND POCONO FORMATIONS, UNDIFFERENTIATED

Mauch Chunk—red calcareous shale, a few feet thick, present only in western part of county.

Pocono—a thick-bedded, gray, coarse sandstone and conglomerate, containing siltstone. Locally, a light-brown mudstone and siltstone are present as a basal unit. Yields small supplies of good-quality water, but is not exploited because of its small areal extent.

MISSISSIPPIAN-DEVONIAN

Dck

CATSKILL FORMATION

Chiefly a red and gray shale and sandstone with some conlgomerate. Adequately supplies most wells in the county; better wells yield 50 to 300 gpm of good-quality water.

DEVONIAN

SYMBOLS

Contact
Dashed where approximate

Primary fracture trace

Secondary fracture trace

Strike of vertical joint

Limit of lowest mined coal bed

Geologic contacts northeast of Scranton where Interstate Route 81 and U.S. Route 611 bisect the Lackawanna Valley are after unpublished work of W. D. Sevon, Pennsylvania Geological Survey. Those contacts southwest were mapped by J. R. Hollowell with the help of W. D. Sevon.

John G. Kuchinski, Cartographic Draftsman

GEOLOGIC MAP OF LACKAWANNA COUNTY, PENNSYLVANIA

BY

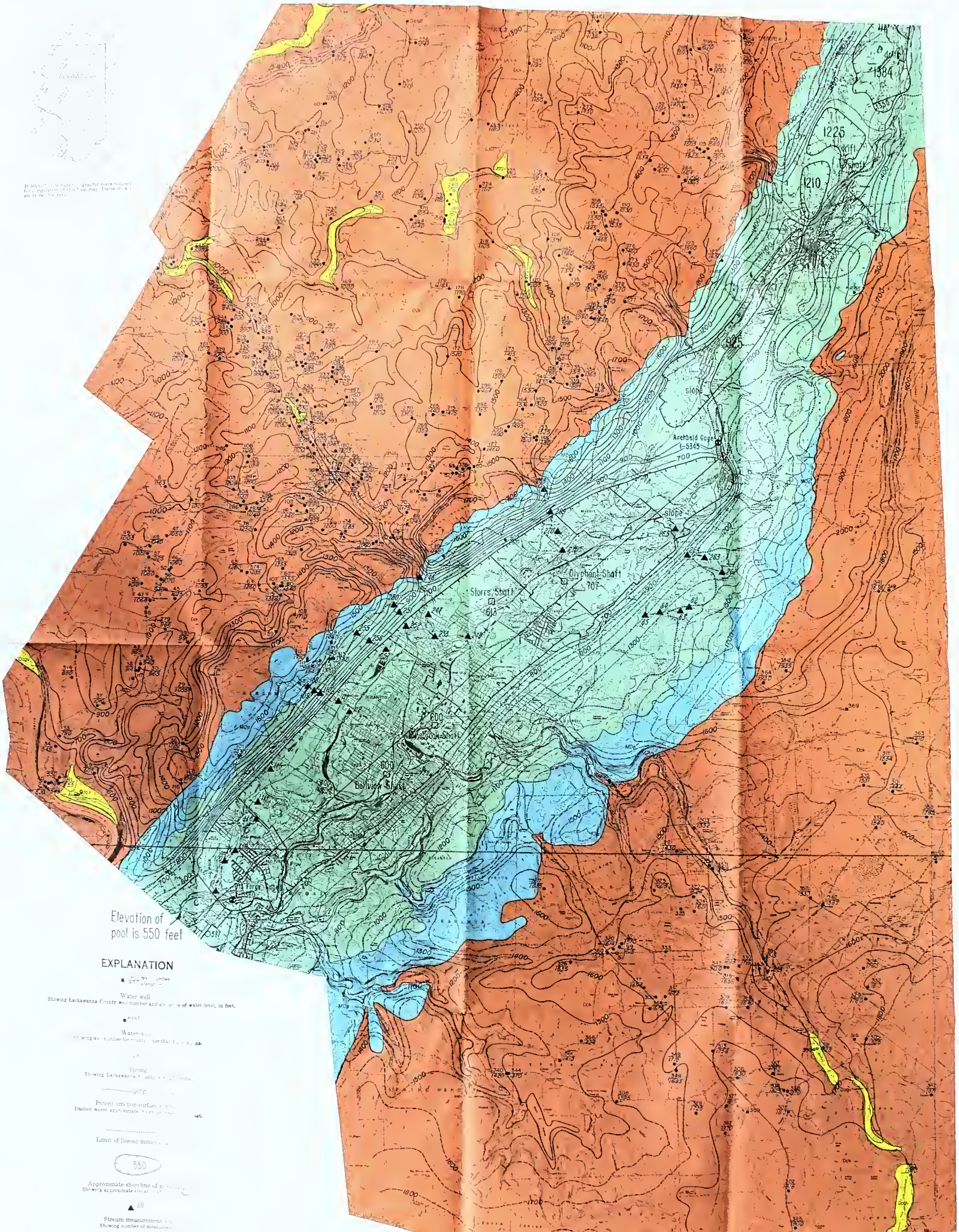
JERRALD R. HOLLOWELL AND HARRY E. KOESTER

1975

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

W 41, Plate 2



EXPLANATION

Water well
Showing Lackawanna County well number and elevation of water level, in feet.

Water well

Spring
Showing Lackawanna County

Potentiometric-surface
Dashed where approximate

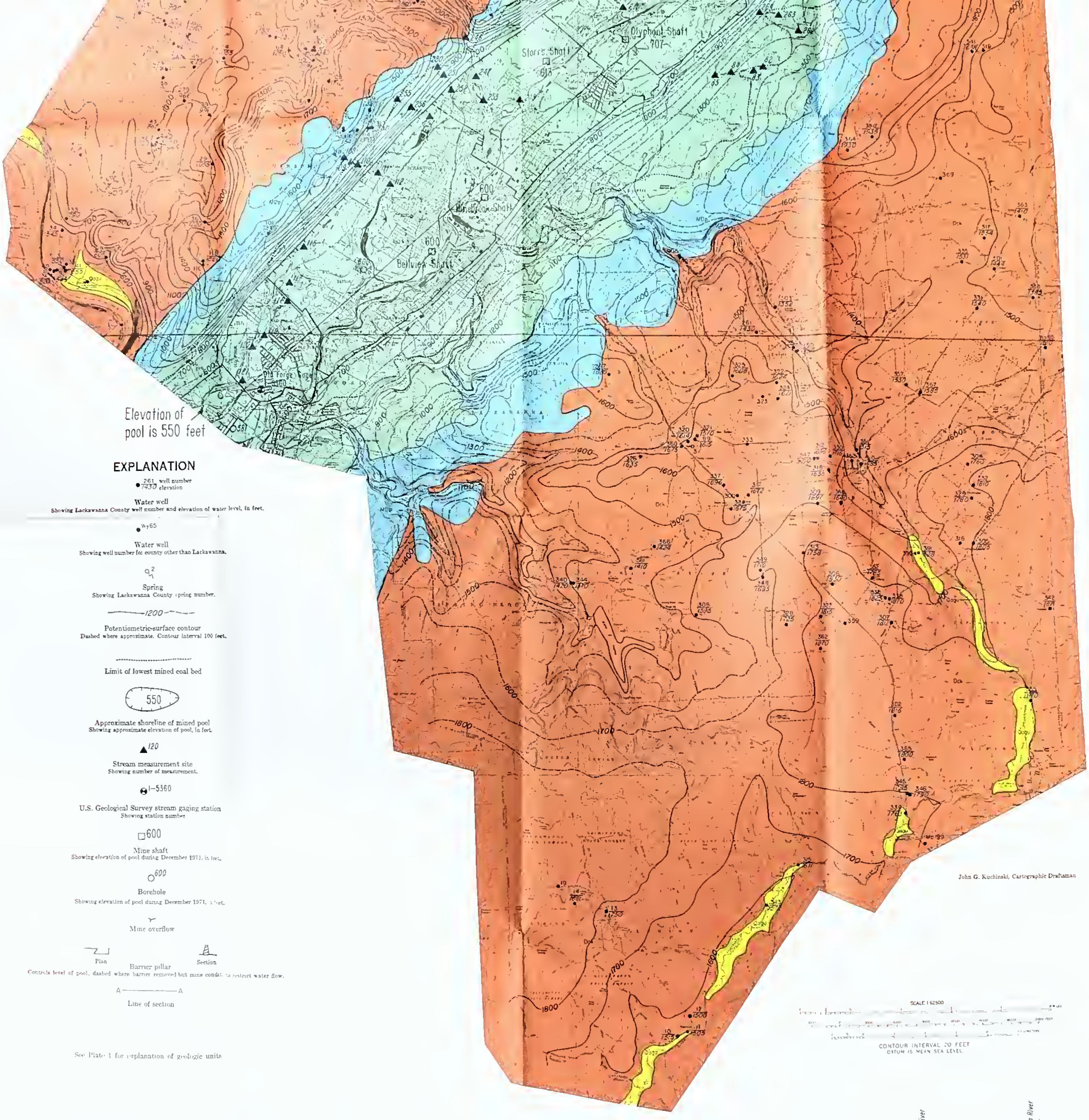
Limit of lowest mine

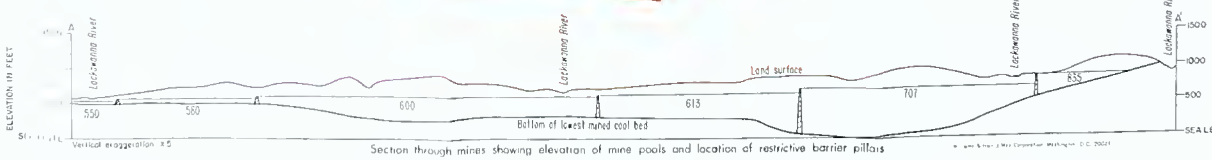
550

Approximate shoreline of
Showing approximate elevation

20

Stream measurement
Showing number of measurements





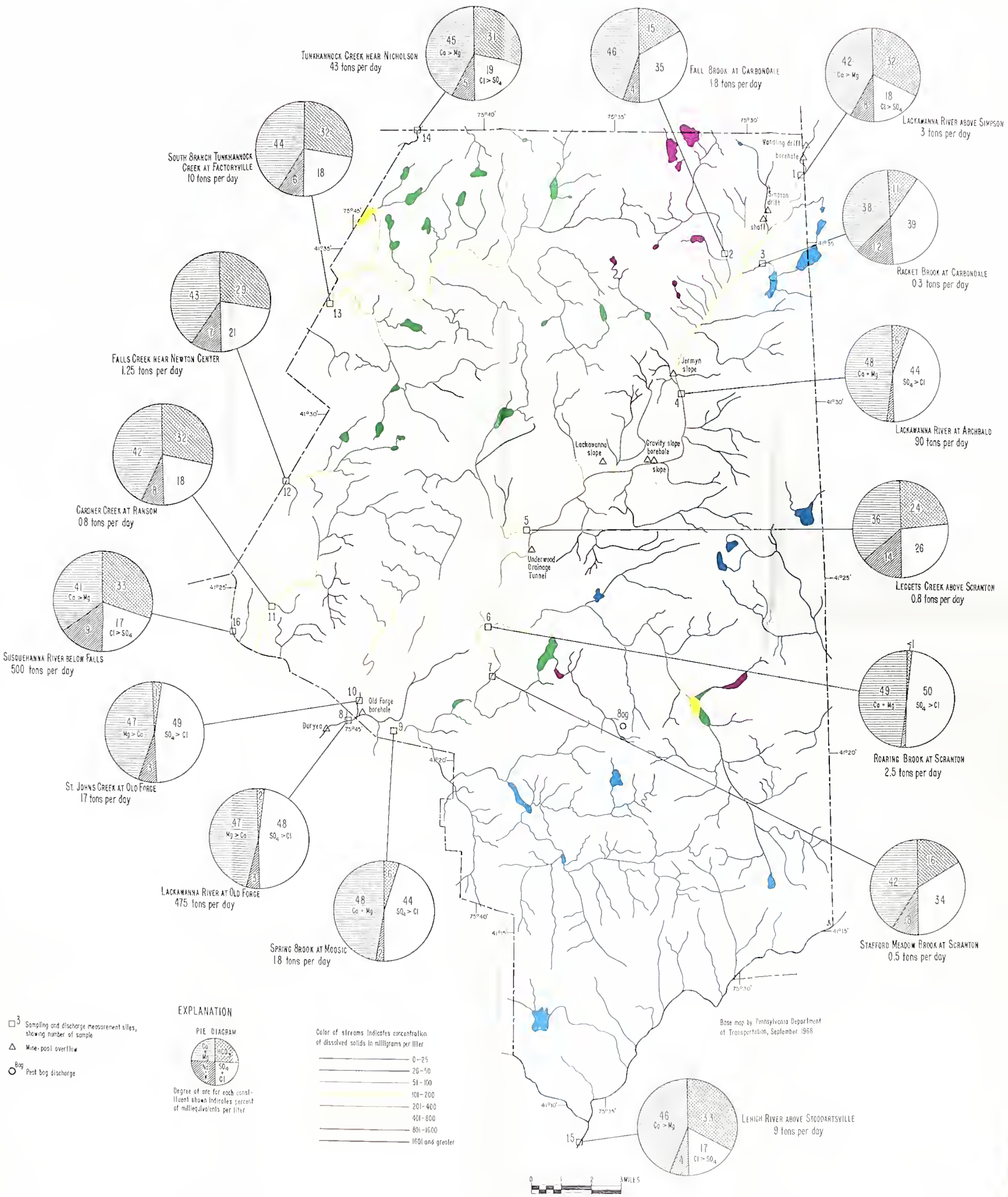
Section through mines showing elevation of mine pools and location of restrictive barrier pillars

WATER-TABLE CONTOUR MAP OF LACKAWANNA COUNTY SHOWING WELL LOCATIONS

BY

JERRALD R. HOLLOWELL AND HARRY E. KOESTER

1975



STREAM MAP OF LACKAWANNA COUNTY, PENNSYLVANIA

SHOWING CHEMICAL QUALITY OF STREAMS DURING LOW FLOW AND GRAPHIC DISPLAY OF CHEMICAL LOADS